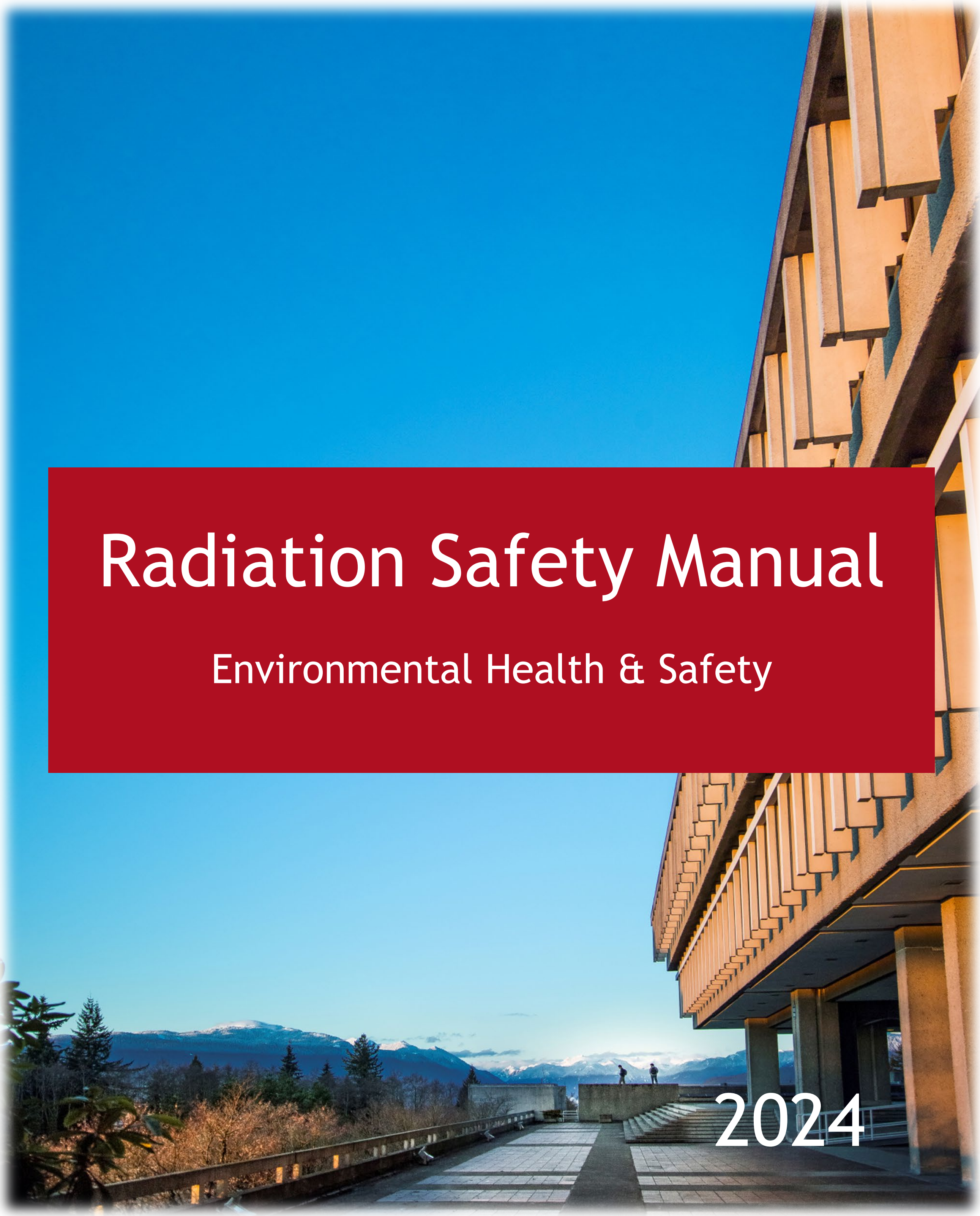
SFU SAFETY & RISK SERVICES | ENVIRONMENTAL HEALTH & SAFETY



Radiation Safety Manual

Environmental Health & Safety

2024

SFU SAFETY & RISK SERVICES | ENVIRONMENTAL HEALTH & SAFETY

This manual was prepared by the Department of Environmental Health and Safety, Simon Fraser University (SFU)

For questions or comments, contact:

Dr. Jutta Rickers-Haunerland, Director, Research & Lab Safety
email: jhaunerl@sfu.ca
phone: 778-782-7265

David Qu, Program Manager, Ionizing Radiation
email: rso-info@sfu.ca
phone 778-782-3633

Record of Changes

Date	Revised by	Revision
March 18 th, 2022	Jutta R.-Haunerland	Content updates
July 12, 2021	Jutta R.-Haunerland	Clarification for NEW classification
July 12, 2021	Jutta R.-Haunerland	Pregnancy updates as per CNSC Regulations
January 12, 2021	Jutta R.-Haunerland	Editorial changes
January 12, 2021	Melanie Gascoine	Additional appendix, corrections
November 14, 2019	Jutta R.-Haunerland	Content updates
October 18, 2019	Alina Tepes	Updated URLs
April 30, 2019	Alina Tepes	Complete reformatting of the manual's template, fonts, and appendices
April 26, 2019	Jutta R.-Haunerland	Editorial changes
April 18, 2022	Jutta R.-Haunerland	CNSC requested content updates

SFU SAFETY & RISK SERVICES | ENVIRONMENTAL HEALTH & SAFETY

Contact Information

SFU Emergencies		
IN AN EMERGENCY CALL 911		
Emergency Support/First Aid Line	24 hours/day at any campus	2-4500 or 778-782-4500
Non-Emergency/Safe Walk Line	24 hours/day at any campus	2-7991 or 778-782-7991

Environmental Health & Safety Contacts			
Jutta R.-Haunerland	Director, Research & Laboratory Safety	2-7265	jhaunerl@sfu.ca
David Qu	Program Manager, Ionizing Radiation	2-3633	dqu@sfu.ca
Hamza Ben Zeglam	Radiation Safety Technician	2-3506	ehs_rst@sfu.ca
Carol Wu	Research Safety Coordinator	2-5979	carol_wu_4@sfu.ca
Binad Karmacharya	Program Manager, Biosafety & Laboratory Safety	2-6740	binab_karacharya@sfu.ca
Miles Garcia	Program Manager, Chemical & Hazardous Waste	2-8633	miles_garcia@sfu.ca
Departmental Contacts			
Animal Research Centre	Nicole Belanger	2-5905	nba36@sfu.ca
Archaeology	Shannon Wood	2-5333	wood@sfu.ca
Biology	Maya Piddocke	2-3301	biscmlo@sfu.ca
Chemistry	Priyadarshini Balaram	2-3350	chlabmgr@sfu.ca
Neutron Generator Facility	K. Starosta	2-8861	starosta@sfu.ca
Earth Sciences	Matt Plotnikoff	2-3298	mattp@sfu.ca
Engineering	Ian McGregor	2-6880	Ian_mcgregor@sfu.ca
Geography	B-Jae Kelly	2-3581	bkelly@sfu.ca
Health Sciences	Darrin Grund	2-5341	dmgrund@sfu.ca
Applied Sciences	Laila Abelseth	604-318-7786	fas_director_tech@sfu.ca
BPK	Van Truong	2-3165	vtruong@sfu.ca
MBB	Christine Beauchamp Deidre de Jong-Wong	2-3991 2-4318	mbbmas@sfu.ca deidre@sfu.ca
Physics	Bryan Gormann	2-3703	phys_mlo@sfu.ca
REM	Elissa Cyr	2-4780	enphilli@sfu.ca

Table of Contents

1. The Radiation Safety Program at SFU

The use of radioactive materials and/or equipment generating ionizing radiation is regulated in Canada by the Canadian Nuclear Safety Commission (CNSC), and provincially by WorkSafeBC. The CNSC issues a consolidated radioisotope license for Simon Fraser University. The license specifies conditions of usage of the prescribed substances. Radiation Safety staff, through internal compliance inspections, monitor compliance with the license conditions and SFU policies and procedures. Within the Compliance Division of the CNSC and WorkSafeBC, inspectors are responsible to ascertain that the requirements of the Nuclear Safety Control Act and CNSC regulations are being fulfilled. They inspect the institution at regular intervals to verify that the University community is in compliance with those regulations and with the radioisotope license conditions (See **Appendix J**: Internal Inspection forms).

SFU's Radiation Safety Program is an integral component of Environmental Health & Safety. The structure of the Radiation Safety Program at SFU is described by policy R20.04, Radiation Safety, available on the web at: http://www.sfu.ca/policies/gazette/research/r20-04.html. It is a condition of this policy that all activities involving radioactive materials at SFU:

- Be justified that no activity using radioactive materials be undertaken unless it can be demonstrated that it will produce a positive net benefit
- Keep exposures to ionizing radiation **A**s **L**ow **A**s **R**easonably **A**chievable, the **ALARA** principle

1.1 The University Radiation Safety Committee (URSC)

The SFU University Radiation Safety Committee (URSC) provides internal auditing of the Radiation Safety program. For a list of current committee members, contact jhaunerl@sfu.ca. It is the responsibility of the URSC to:

- Ensure the development, implementation and compliance with policies, regulations and procedures for ordering, safe use, handling, monitoring, storage and disposal of radiological materials which fall under the legislative control of the CNSC and of the use of equipment that emits ionizing radiation regardless of the source of authorization at the University
- Review, at least annually, the entire Radiation Safety Program to determine if all activities meet the conditions of the license and the CNSC Regulations
- Receive reports from the Director of Research and Laboratory Safety and recommend remedial action to correct any deficiencies
- Review the annual report prepared by Program Manager, Ionizing Radiation Safety and once approved, forward a copy of this report to the CNSC and the Vice-President, Research
- Review actions taken by Program Manager, Ionizing Radiation Safety for non-compliance with CNSC and other rules and regulations (see Section 2. Measures to Promote the Safe Use of Radioactive Materials)
- In general, act as the internal auditor of the functioning of the Radiation Safety Program at Simon Fraser University

- Recommend changes to this policy to the Vice President, Research, who has the authority to approve such changes

1.2 The Radiation Safety Program

The Radiation Safety Program is one of several research safety programs reporting to the Director, Research and Laboratory Safety. The Program Manager for Ionizing Radiation functions as the Radiation Safety Officer. The following activities are essential activities of the Radiation Safety Program:

- Plan, develop and manage a radiation safety strategy to promote compliance with the regulations of the CNSC, other federal and provincial bodies, and conditions of the University radioisotope license
- Develop, recommend and implement policies and procedures for the safe use of Radioactive Materials in accordance with the current CNSC guidelines and those of other pertinent regulatory agencies
- Advise the Vice-President, Research and the Chief Safety Officer on matters related to radioactive hazards and radiation safety, including the resources necessary to set up and maintain an adequate Radiation Safety Program in conjunction with ALARA principles
- Advise the University Radiation Safety Committee (URSC) on matters regarding radiation safety
- Be available for consultation on problems dealing with radioactive materials and radiation hazards
- Prepare, update and arrange for the distribution of the "SFU Radiation Safety Manual," containing all information pertinent to the use of radioactive materials at Simon Fraser University
- Receive applications for and give detailed review to all proposed uses of radioactive materials and equipment which the University has been licensed by the CNSC to acquire and use
- Designate local conditions for radiation protection for each application; these shall be consistent with the conditions of the consolidated license and the requirements of the regulations, policies and procedures for radiation safety at Simon Fraser University and with ALARA principles
- Issue permits approved by the Radiation Safety Officer, the Director, Research and Laboratory Safety and the Chair of URSC for proposed uses and users within the University subject to compliance with the conditions specified above
- Develop and maintain a certification training program to ensure that all individuals who may be required to work with radioactive materials are properly instructed
- Develop, deliver and maintain training and information programs to ensure that all employees who may be required to work in the vicinity of radioactive material are properly instructed
- Designate any individual to be considered as an Nuclear Energy Worker (NEW) under the CNSC Regulations
- Maintain written records of all meetings, action, incidents or unusual occurrences and recommendations, as well as decisions, and forward a copy of these records to the CNSC
- Approve designs of new laboratories and the decommissioning of existing laboratories in accordance with CNSC regulations
- Align policies, procedures and protocols of the Animal Resource Centre (ARC) and the Biosafety

Program regarding radioisotope use in authorized labs with the Radiation Safety Program policies, procedures and protocols

- Ensure by regular inspections that proper procedures are in place to control the purchases, storage, use, disposal and transport of radioactive materials
- Ensure that records associated with use of radioactive materials are properly maintained
- Investigate reports of user infractions of policies, procedures and guidelines and initiate corrective and/or disciplinary action
- Maintain a program of required leak-testing of sealed sources on campus
- Maintain a dosimetry program for personal-exposure monitoring
- Develop and coordinate emergency response for incidents involving radioactive materials; supervise decontamination operations where required
- Prepare the Radiation Safety Annual Compliance Report according to CNSC guidelines
- Prepare when requested by the CNSC the renewal application for the University radioisotope license
- Audit the University Radiation Safety Program to identify deficiencies and initiate steps to address outstanding issues
- Enact the Enforcement Policy to ensure that compliance is maintained
- Conduct investigation of all incidents involving radioactive materials, and recommend corrective actions to prevent reoccurrence

1.3 The Permit Holder

The permit holder is an employee of the University, typically a faculty member, who has training and experience that is acceptable to the Radiation Safety staff, in the safe handling of radioactive materials and devices. The permit holder is responsible to:

- Initiate a review and seek prior approval from Radiation Safety staff for any research and/or teaching program using radioactive materials
- Ensure that safe laboratory practices are followed in compliance with the University's radiation protection standards and the safe laboratory practices stated in the current revision of the CNSC "Laboratory Rules Poster"
- Ensure that operations involving radioactive materials are performed only in locations authorized in the permit
- Ensure that only individuals authorized on the permit perform operations with radioactive materials
- Ensure that all users have received adequate radiation safety training or experience and have been informed of the risks of exposure to ionizing radiation. Permit holders are responsible for providing specific training in radioisotope handling that is necessary for the safe use of radioisotopes in their laboratories
- Designate specific work and storage areas for radioactive materials and ensure that these areas are clean, properly labeled and have adequate ventilation and shielding

- Post warning signs and labels as required by the CNSC and University regulations and policies
- Ensure that personnel wear appropriate radiation badges or pencil dosimeters when and if required
- **Maintain an inventory of radioactive materials** used in his or her project(s), and ensure that the activity in hand does not exceed the limits authorized in the permit
- **Maintain records** of the disposal of radioactive materials
- Allow only authorized persons to enter rooms that are specified as restricted areas for reasons of radiation safety
- Establish a laboratory procedure to ensure, at the end of the laboratory work day, that:
  - Survey-meter measurements and/or wipe tests have established that external radiation and contamination levels are within permissible limits
  - Radiation sources are properly labeled and securely stored
  - Experiments that will be in progress after normal working hours will be either properly attended or secured
  - Each laboratory is secured against unauthorized access
- Ensure that weekly contamination swipe tests are performed and the results recorded
- Report promptly to Radiation Safety staff all incidents involving release, loss or theft of radioactive materials
- Ensure compliance with all relevant standards including CNSC guidelines and Simon Fraser University's Radiation Safety policies and procedures
- Develop, in cooperation with Radiation Safety staff, appropriate emergency and decontamination procedures for his/her area of work
- Ensure that all operations comply with the conditions of the permit

Animal Resource Centre (ARC)

For permits including the use of radioisotopes in authorized labs within ARC all ARC policies and procedures apply in addition to policies, procedures and protocols laid out in the Radiation Safety program. Researchers are to provide detailed experimental protocol to Radiation Safety staff for protocol and procedures assessment prior to start of research project.

ARC uses FOB controlled doors for access control. Emergency exits can only be opened from inside. Fire alarm by the entrance is connected directly to Campus Security. The authorized radioisotope lab within ARC has required signage with updated contact information and phone numbers posted at the door, as well as in-house permit indicating type of radioisotope in use, radiation sign to indicate radiation hazard. ARC procedures prescribe use of disposable animal cages, feeding trays, water bottles, padding etc.. For anything which may come into contact with radioisotopes radioactive labels are applied. Two layers of disposable personal protective equipment (PPE) and double-gloves are worn by personnel working the authorized lab. All items, equipment etc. are swipe tested, surveyed, prior to conclusion of experiments and the clean-up procedures. Waste gets bagged according to the Waste Handling **(App. G**) chart in the RSM. All non-disposable utensils and equipment is wiped down with 'Count-Off' and swipe tested before return to use or storage. All bagged waste after swipe testing is brought by researchers to the EHS 'radionuclide lab' , Hot Lab, for proper disposal. ARC SOPs, see **Appendix X**.

1.4 The Authorized User

Radioisotope users must be authorized by Radiation Safety staff to handle radioactive materials and their name must appear on the permit of the permit holder for whom they wish to work. Authorized users are required to:

- Have a working familiarity with SFU's Radiation Safety policy and procedures
- Follow specified work procedures
- Use appropriate protective equipment
- Report promptly to the Permit Holder and to Radiation Safety staff any incidents, loss, theft or accidents involving the use of materials
- Bring to the attention of the permit holder any defect in the operation of which they are aware

2. Measures to Promote the Safe use of Radioactive Materials

The failure of an individual to conform to the conditions of the radioisotope license issued to the University by the CNSC may result in severe consequences for the University as a whole. These consequences may include a threat to the safety of the campus or surrounding community and environment, the loss of the license and immediate cessation of all research involving radioactive materials by all users, and substantial monetary fines. As a result, the University Radiation Safety Committee has established a policy to ensure that the license conditions will be met.

2.1 Principles

- Undue risk to the workers, the environment and/or to public safety will be met with prompt corrective action
- CNSC's rules are designed to ensure public safety. If there are special cases for which they do not make operational sense, the Program Manager, Ionizing Radiation will request a suitable amendment or exemption to the Simon Fraser University radioisotope license
- The permit holder is responsible to provide a safe environment for those working under his/her permit and to ensure that work is conducted according to regulations
- The Program Manager, Ionizing Radiation has the authority and the responsibility to initiate corrective and or punitive actions when and where warranted
- Violations of the terms of this policy may result in disciplinary action

2.2 Procedures

- If danger to public safety is observed then, apart from any other action, the dangerous situation will be rectified promptly and those responsible for creating the situation will have their permission to work with and/or use radioactive materials immediately suspended.
- For record keeping deficiencies, coffee cup/food offences, other similar unsafe practices and violations of permit conditions:

  1st offence: written warning to the permit holder and the offender, with a record of the warning on file; cups and food will be confiscated if not removed promptly after the warning

  2nd offence: (includes items of noncompliance found during a re-inspection) written notice to the permit holder and the offender stating that any further infraction will result in suspension of the permit; immediate confiscation of cups and food

  3rd offence: suspension of the permit with notification to the Department Chair and to the University Radiation Safety Committee (URSC). Work under this permit will be allowed to resume once the permit holder has provided a written review of utilization of radioactive materials under the permit in the past 6 months and a satisfactory plan for compliance for the future. The offending individual will be removed from the list of authorized users and can only obtain reinstatement by attending the Radiation Safety course to the satisfaction of Radiation Safety staff

Offences over a year old will not be counted, and offences of distinctly different natures will be counted separately.

- If, after reinstatement there are further infractions, the individual will be removed from the list of authorized users and the permit suspended; the permit holder may appeal to the URSC for restoration of the permit and reinstatement of the offender. The committee may recommend:
    - Cancellation of the permit until the permit holder satisfies conditions deemed appropriate by the URSC
    - No reinstatement of the offending individual
    - Further attendance at a Radiation Safety course
    - Work permitted under continuous visual supervision
    - Other restrictions or actions deemed appropriate

If, in the opinion of Radiation Safety staff, there is a major violation of the terms of this policy, an allegation of misconduct may be filed against the individual responsible. Examples of major violations include, but are not limited to, unauthorized, mischievous or malicious uses (or unauthorized, mischievous, malicious interference with approved uses) of radioactive materials and intentional disregard of any of the regulations governing the safe handling of radioactive materials. If this occurs in a research setting, an allegation of misconduct in research may be filed under Simon Fraser University Policy R60.01. If this occurs in a non-research setting, an allegation of misconduct may be recorded under the terms of the policy or collective agreement relevant to that setting and to the employee or student group to which the alleged offender belongs. If there is no appropriate policy or collective agreement for consideration of the allegation, it may be filed with the Vice President, Research and considered according to the procedures contained in Simon Fraser University Policy R60.01, which can be viewed at http://www.sfu.ca/policies/gazette/research/r60-01.html

2.3 Appeals

Decisions made by Radiation Safety staff may be appealed to the URSC whose decisions are final. Appeals of other decisions, made under the provisions above, may be made through the appeal or grievance mechanism contained in the policies applied therein.

3. Training Requirements

Versions of the Radiation Safety training are offered to the following campus groups:

- Research personnel
- Campus Trades personnel
- Campus Safety and Security personnel
- Science Stores personnel
- Janitorial personnel

The URSC has made it a requirement that all new prospective users or new internal permit applicants, regardless of previous training, must complete Radiation Safety Training at SFU. Since the training is usually offered semesterly, new users may begin **radioisotope work prior to taking Radiation Safety Training** under the following conditions:

- If they are **new radioisotope users** or **have previous experience and training in the use of radioisotopes**, but are **new to SFU**, they may begin radioactive work once they are authorized by the RSO. To become an authorized user the **online Radiation Safety Orientation training** is offered on demand, and is followed by **a hands–on training component** with the **Radiation Safety Technician (RST).** The practical session provides training in SFU procedures for ordering and handling of radioisotopes. Radiation Safety staff has to be contacted for registration of the online course.

  Afterwards, they must undertake all radioactive work **under the direct line-of-sight supervision of a trained and authorized radioisotope user until they have completed the full Radiation Safety course.** It is recommended to enroll in the full Radiation Safety course at the next available offering.

In either of these above cases, should these users not complete the next available Radiation Safety Training Course, their radioactive work privileges will be suspended and in the case of permit holders, their permits will be revoked until they complete the required training.

3.1 Radiation Safety Training Available at SFU

For Research Personnel

To view current training schedule, visit:

https://www.sfu.ca/srs/work-research-safety/research-safety/radiation-safety/training-orientation.html

To register for the full **Radiation Safety** training, visit www.sfu.ca/srs/lab-safety-training

> **Note:** If you have missed the semesterly offering, please contact the Radiation Safety staff to register for the **Radiation Safety Orientation online** training, followed by a 2-hour **hands-on component** with the RST.

Refresher training is recommended every 3 year and available online on demand, to register, please visit: https://www.sfu.ca/srs/training.html

Sealed sources and Portable Gauges training is available online on demand, to register, please visit: https://www.sfu.ca/srs/training.html

For Principle Investigators (PIs)

To register for the **PI Radiation Safety training**, on demand, online, please visit: https://www.sfu.ca/srs/training.html

For the remaining training groups

Special training dates can be arranged with the Program Manager, Ionizing Radiation. Please send all inquiries to radsafe-info@sfu.ca

4. Authorization to use Radioactive Materials

4.1 The Radioisoptope Permit

At minimum, **two months prior to undertaking radioactive wor**k, a researcher must submit an application for an internal permit to Radiation Safety staff outlining the research project, the isotope(s), and expected quantities to be used. Applications for a radioisotope permit are available in **Appendix A** - Permit Application form. Once issued, a copy of the permit has to be posted on the outside of the door of each authorized room.

4.2 Amendments of Permits

Permit holders are responsible for notifying the Program Manager, Ionizing Radiation of any changes in authorized personnel, rooms, radioisotopes in use, or projects. Notification can be made via email.

4.3 Renewal of Permits

- Permits expire on the date specified on the existing permit
- Preceding the expiration date there will be a period of conditional approval. This period is indicated on the permit
- At least a month before the start of the conditional approval period the Program Manager, Ionizing Radiation will contact the permit holder to determine whether renewal is required and if any amendments are necessary
- If no requests for renewal have been received by the Program Manager, Ionizing Radiation at the start of the conditional approval period the permit will have expired at that date, otherwise the permit will be extended to the expiry date
- A current inventory of radioactive materials in stock has to be verified and provided on an annual basis

4.4 Teaching Permits

The teaching of laboratory courses in which radioisotopes are handled requires that the person in charge of the course obtain a temporary permit from the Program Manager, Ionizing Radiation. This authorization will be granted at the beginning of each term once the following information is received:

- Instructor name, class list, outline of experiment(s) involving radioactive materials

Radiation Safety staff will issue the temporary permit if the experiment(s) are approved. One of the conditions of the permit is that a safety presentation be given to the students at the beginning of the term by Radiation Safety staff or an approved individual (usually the course instructor).

5. Acquiring Radioactive Material

5.1 Ordering Procedure

- The Program Manager, Ionizing Radiation or the Radiation Safety Technician (RST) must approve all purchases of items or apparatus containing radioactive sources. An online order system is available through Financial Services. Radioactive items need to be indicated on the order requisition for the approval process
- The requester should be an approved user
- The quantity of material ordered cannot exceed the possession limit indicated in his or her internal permit
- Because of the Nuclear Non-Proliferation Treaty, some radioisotopes are safeguarded and cannot be imported into Canada without a permit. See **Appendix B** for a list of items requiring an import permit. Contact Radiation Safety staff well in advance of your study if you wish to import any of the listed items. The status for unlisted items may differ as the import requirements may change, therefore it is recommended to verify with Radiation Safety staff whether import permits are required.

Also see https://www.sfu.ca/srs/work-research-safety/research-safety/radiation-safety/specific-procedures.html for information regarding acquiring radioactive materials.

5.2 Transfer of Radioactive Materials

The Program Manager, Ionizing Radiation, or the Radiation Safety Technician must approve transfers of radioactive materials to or from another laboratory at SFU or at another institution, or to an individual off-campus. Incoming transfers must have an inventory sheet issued by the RST and have to be included in lab inventories.

5.3 Transportation of Radioactive Materials

Transport Canada Dangerous Goods Regulations and the Packaging and Transport of Nuclear Substances Regulations regulate the packaging and transportation of radioactive materials within Canada. Anyone packaging, transporting, shipping or receiving radioactive substances must hold a valid Transport of Dangerous Goods Certificate for Class 7 Radioactive Materials by road and air. **Shipments of radioactive materials to or from SFU must be arranged through Radiation Safety staff.**

Note: For more detailed information on TDG 7 guidelines, please refer to the "Guide to Transportation of Dangerous Goods" Manual, which can be found here: https://www.sfu.ca/srs/work-research-safety/research-safety/lab-safety/transportation-of-dangerous-goods.html

6. The Radiation Area

6.1 Laboratory Design

Radioisotopes are to be used only in those laboratories that conform to the specifications of the Canadian Nuclear Safety Commission and Guidance Document GD-52, "Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms." To set up your lab space, please print and fill out **Appendix U**—Radiation lab set-up checklist.

- The radiation handling area should be set up to minimize movement of radioactive materials
- The laboratory should be at negative pressure relative to other areas
- A fume hood is mandatory if radioactive aerosols or gases are to be used
- Fume hoods should not be located near the entrance to the laboratory
- All surfaces and furniture shall be finished with smooth, impervious, washable, and chemical resistant finish
- Chairs or stools are required to be covered with a vinyl or plastic sheet
- **Radioisotope laboratories** must have **sufficient floor and countertop space to allow persons to work safely**; three square meters of free floor area per person should be provided
- No food or beverage preparation, consumption or storage in the lab
- No desks or study facilities in radioactive handling areas.
- Provision should be made for emergency lighting in the lab

See **Appendix P** for laboratory design requirements

6.2 Bench Preparation and Location

- The radiation bench should be located to minimize movement of radioactive materials
- The radiation bench area must be clearly delineated with radiation warning tape
- Bench cover should be used with the absorbent surface facing up
- Where large volumes of liquids are handled the work should be done in diaper-lined trays such that if a spill does occur **all the liquid is contained**

6.3 Laboratory Classification

A laboratory is not deemed radioactive unless there is more than 1 Exemption Quantity (EQ) in use. Table 1 (below) lists the EQ value for some commonly used radioisotopes. A list of Radiation Measurements and Units can be found in Appendix W.

The CNSC has four categories of radioactive laboratories: Basic, Intermediate, High Level, and Special Purpose. The laboratory classification is determined by the radioisotope in use and the potential exposure. Potential exposure is characterized by the **Annual Limit of Intake (ALI)**, which is the amount of isotope, which if ingested or inhaled, would result in a yearly committed effective dose of 20 mSv. The laboratory classification is determined by the number of ALIs used at one time in the laboratory (See Table 2 below for the ALIs and associated laboratory classifications).

Table 1: Exemption quantities (EQs) for commonly used radioisotopes

ISOTOPE	Exemption Quantity (MBq)
P-32	0.1
C- 14	10
H- 3	1000
P-33	100
I-125	1
S-35	100

Note: Laboratories in which sealed radioactive sources are used and storage areas are not classified, although they still require an internal SFU radioisotope permit if the activity of sources exceed the exemption quantities. Shielding shall be provided to ensure that workers are not exposed to radiation levels in excess of 25 µSv hr^{-1} (2.5 mRem hr^{-1}); in most cases, workers should be shielded so that fields do not exceed 2.5 µSv hr^{-1} (0.25 mRem hr^{-1}). ALIs and appropriate laboratory classifications for some commonly used radioisotopes are given in Table 3

Table 2: Radioisotope laboratory classifications

Laboratory Designation	Number of ALI's
Basic	≤5
Intermediate	≤50
High Level	≤500
Special Purpose	requires written permission from the CNSC

Table 3: ALI and maximum amount to be used on the open bench according to the laboratory classifications for commonly used radionuclides

ISOTOPE	ALI (MBq)	Maximum amount to use in Laboratory (MBq)		
		BASIC	INTERMEDIATE	HIGH LEVEL
P-32	8	34.5	345	3450
C-14	34	170	1700	17000
H-3	1000	5000	50000	50000
P-33	75	75	750	7500
I-125	1	6.5	65	650
S-35	26	90	900	9000

6.4 Posting of Signs and Labels

Posting requirements for rooms in which radioactive materials are used or stored vary depending on the type of source and usage. See Table 4: Posting requirements for radioactive areas, for specific requirements.

Table 4: Posting requirements for radioactive areas

Laboratory Type	Current Permit	24-hour contact Information	Radiation Warning Sign	"In Use" Sign	Safety Rules Poster
Open Source	X	X	X	X	X
Sealed Source	X	X	X	X	
Storage Area	X	X	X		X

i. Posting of the Radioisotope Permit

Any room that contains radionuclides in excess of one Exemption Quantity must have been approved by the Program Manager, Ionizing Radiation Safety and must be designated in a current radioisotope permit. Any enclosure, room, storage container, refrigerator or cupboard containing radioactive materials must be labeled as to the nature of the radioactive materials and corresponding activities (See Table 1 for Exemption Quantities). To this end, the Radioisotope Permit must be posted on the outside of the door of all approved locations.

ii. 24-Hour Contact Information

All areas in which radioactive materials are used or stored must be labeled with the name and phone number of a person who can be contacted 24-hours a day in case of an accident or incident. Emergency Contact Telephone Numbers for the Program Manager, Ionizing Radiation should be posted on the door of **every room approved for radioisotope use.**

iii. The Radiation Warning Sign

If more than 100 EQ of radioactive materials are present, or there is a reasonable chance that a person may be exposed to an effective dose rate of greater than 25 μSv/hr (2.5 mR/hr), the room, vehicle or enclosure must be labeled with words: "DANGER – RADIATION- RAYONNEMENT" and the trefoil symbol in magenta or black on a yellow background (see Figure 1).

Figure 1: Radiation Warning Sign

iv. The "In-use" Sign

The appropriate "IN USE" sign should be posted in the radiation work area when radioactive materials are in use and removed when the radioactive work is discontinued. See sample Figure 2.

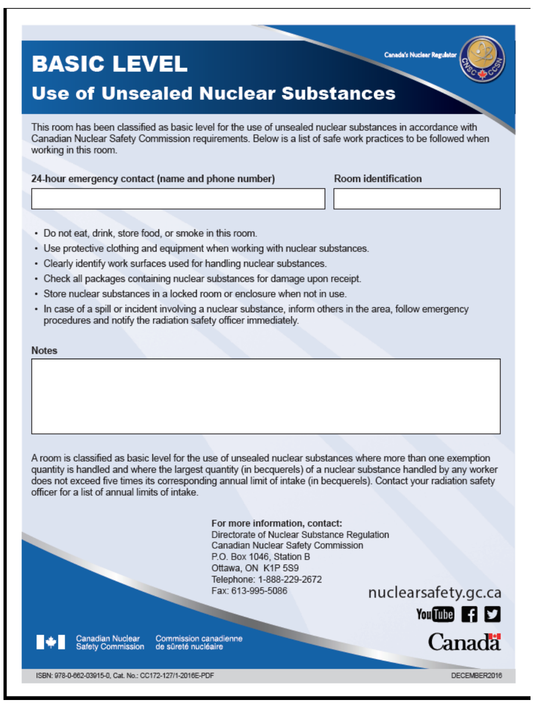
Figure 2: example "In-Use" Sign

C-14
IN USE

v. The Radioisotope Safety Poster

The appropriate lab rules poster issued by the CNSC entitled "Use of Unsealed Nuclear Substances" must be posted inside labs using open sources in the radioisotope working area. For laboratories designated Basic, the blue Lab Rules poster entitled "Basic Level: Use of Unsealed Nuclear Substances" is to be used. For those labs designated as Intermediate, the orange Lab Rules poster entitled "Intermediate Level: Use of Unsealed Nuclear Substances" is to be used. For laboratories designated as High Level, the poster must be approved by the CNSC.

Figure 3: CNSC 'Lab Rules' Posters (Basic and Intermediate Levels)



BASIC LEVEL
Use of Unsealed Nuclear Substances

Canada's Nuclear Regulator

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

24-hour emergency contact (name and phone number) | Room identification

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

Notes

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

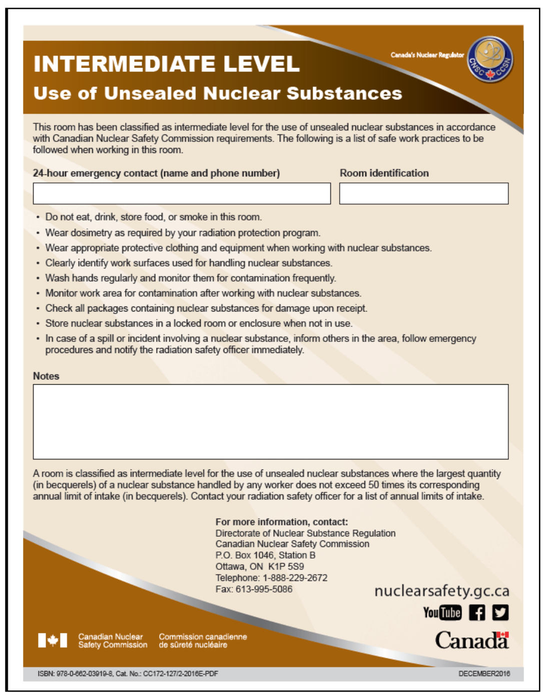
For more information, contact:
Directorate of Nuclear Substance Regulation
Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
Ottawa, ON K1P 5S9
Telephone: 1-888-229-2672
Fax: 613-995-5086

nuclearsafety.gc.ca

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canada

ISBN: 978-0-662-03915-0, Cat. No.: CC172-127/1-2016E-PDF DECEMBER2016



INTERMEDIATE LEVEL
Use of Unsealed Nuclear Substances

Canada's Nuclear Regulator

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

24-hour emergency contact (name and phone number) | Room identification

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

Notes

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

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

nuclearsafety.gc.ca

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canada

ISBN: 978-0-662-03919-8, Cat. No.: CC172-127/2-2016E-PDF DECEMBER2016

7. Types of Ionizing Radiation

Alpha, beta, gamma and X-ray radiation and neutrons are characterized by ionizing radiation simply because they carry enough energy to cause ionizations during their interactions with any matter, i.e. a body, air, water. The efficiency with which it creates these ionizations depends upon the energy of the radiation emitted and the type of radiation. Note: Normally, alpha, beta, X-rays and gamma rays cannot cause materials to become radioactive, while neutrons can activate or turn previously inactive materials into radioactive materials.

7.1 Alpha Emitters

Alpha particles are positively charged helium nuclei. On a nuclear scale, they are quite large and travel for short distances, even in a medium of low density. As a result, a sheet of paper or a thin layer of skin can stop them. They are, however, considerably more hazardous if ingested. Since they will deposit all of their energy within the body, they cause internal damage, particularly to the lungs if inhaled.

7.2 Beta Emitters

Beta particles are characterized by fast moving electrons, which are emitted during certain type of radioactive decay. They are small compared to alpha particles. Low energy beta particles, such as those emitted by tritium (H-3), Carbon-14 (C-14), Sulphur-35 (S-35), and Phosphorus-33 (P-33) cannot even penetrate Plexiglas, and likely will not penetrate the dead layer of the skin. High energy beta particles from **Phosphorus-32 (P-32**) require ¼ inch Plexiglas shielding to be stopped and may cause damage to the eye and skin. Consequently, users handling stock solutions of **50 MBq or more are requested to wear finger ring badges to monitor skin dose**. Ingested, beta particles become more hazardous since the tissue will absorb practically all their emitted energy.

7.3 X-ray and Gamma Emitters

X-rays and gamma radiation are forms of electromagnetic radiation (similar to visible light) and as such can behave as both, a wave and a particle. While they represent the same physical phenomenon, the different appellation reflects different origin. X-rays emissions result from electronic transitions between inner atomic orbitals. Gamma rays originate from nuclear transitions from within the nucleus of the atom.

Both gamma rays and X-rays have a long range in air and hence, present an external hazard. Their ability to penetrate the human body is one of the reasons for their utility in medical diagnosis. However, since they can penetrate wood and concrete, shielding with a high density material is required. Normally lead shielding is used, either in the form of a lead "pig" container, lead brick or thin lead sheets. Internally, they can still cause damage, but to a much smaller degree, since they pass through the body. Examples of X-ray/gamma-ray emitters used at SFU are Iodine-125 (I-125) and Cobalt-57 (Co-57).

When working with gamma rays and X-rays, increasing the handling distance is a very simple and effective way to reduce body exposure. For high activity sources, where possible, remote handling tools should be used to increase the distance from the source (See Section 10.2).

7.4 Neutrons

Neutrons are subatomic particles with no net electric charge and a mass slightly higher than that of a proton. Neutrons and protons constitute the nuclei of atoms. Neutrons and protons are bound together by nuclear force; they are required for the stability of nuclei. Neutrons are produced in nuclear fission and fusion. A free neutron is unstable.

Neutrons lose their energy only by direct collision with the nucleus of the atom or by nuclear reaction. They are also difficult to detect directly. A common method for detecting neutrons involves converting the energy released from neutron capture reactions into electrical signals. Concrete, water and paraffin are good shielding materials for this class of particles.

Neutron generators are neutron source devices which contain compact linear particle accelerators which produce neutrons by fusing isotopes of hydrogen. The **Nuclear Science Laboratory (NSL)** at SFU provides access to a Thermo Fisher Scientific P-385 deuterium-tritium **neutron generator** producing 14.2 MeV neutrons at a nominal rate of 3×10^8 neutrons/second, as well as a selection of 'state of the art' gamma ray and light-ion detectors.

8. Methods of Detection

Gamma, beta and alpha radiation create ions in their interactions with matter and deposit some of their energy through complex processes. This energy transfer results in excitation, ion pair production, and/or other types of damage in the stopping medium, making it possible to detect these forms of ionizing radiation through various monitoring techniques. It is essential to be aware of the limitations of these monitoring techniques to avoid a false sense of security. The type of detection device to be used depends on the penetrating power and the efficiency of energy transfer (linear energy transfer, LET) of the particular radiation.

In accordance with CNSC expectations (REGDOC 1.6.1) Radiation Safety staff sends survey meters for **Calibration Service** at BCIT once per year or as required.

At SFU, there are three principle modes of detection used:

- Solid scintillator contamination meter
- Geiger-Mueller contamination meter
- Swipe tests/liquid scintillation.

8.1 Solid Scintillators

Gamma radiation, being more penetrating and more difficult to stop than beta or alpha radiation requires a detection device of higher density then a gas. Various materials, such as thallium activated sodium iodide crystal, when struck by radiation, convert part of the energy to light. The number of photons thus generated is proportional to the energy deposited. The scintillator is optically coupled to a photomultiplier tube which generates a voltage pulse proportional to the number of photons detected (i.e., proportional to the energy deposited). The whole assembly is encapsulated in a lightproof casing. Other types of solid scintillators include silver activated zinc sulfide, organic crystal like anthracene, or organic scintillators embedded in a polymer matrix (plastic scintillators).

8.2 Geiger-Muller Tubes

Geiger-Müller (GM) tubes are the best known and most popular radiation detectors; they are rugged, versatile and relatively inexpensive. In these devices, the detector material is a gas filling a conducting tube with a thin wire at its axis. A high voltage is applied between the tube and the wire. Somewhere on the tube is a thin window of low density material. Radiation penetrating the tube and interacting with the gas will create an avalanche of ion pairs which are collected on the wire, resulting in a voltage pulse. This pulse is processed into a signal, visual (deflection of a needle on a meter), audible (click in a speaker) or digital (for computer processing).

GM detectors are used primarily as contamination check instruments, to indicate the presence of a radiation field, but they cannot give direct information on the type or energy of the radiation. Radiation Safety also has one survey meter, which has internal compensation to allow measurement of exposure. Due to the nature of the detecting material (gas), they are most effective with high Light energy transfer(LET) radiation (beta radiation or low energy gamma) providing that the radiation has sufficient energy to penetrate the window. Table 5 lists the GM detection efficiency for a selection of commonly used radioisotopes.

Table 5: GM detector efficiency (detector equipped with thin window, 1-2mg/cm^2

ISOTOPE	$E_{\beta MAX}$ (MeV)	DETECTOR EFFICIENCY (%)
H-3	0.018	0
C-14	0.156	4 - 10
S-35	0.167	5 - 11
Ca-45	0.252	10 - 20
P-32	1.71	20 - 35

8.3 Swipe Tests

In this type of detection system, the detecting material is a scintillator in solution ("cocktail"). The surface to be tested is wiped over a standard size area (usually 100 cm^2) with a small piece of wet absorbent material (filter paper, cotton wool). The swab is stuffed into a glass or plastic scintillation vial to which a few milliliters of the cocktail is added. The radioactive emission "excites" the scintillation cocktail, which in turn emits a burst of photons; the number of photons is proportional to the energy of the radiation emitted. The photons travel to a photomultiplier tube, which again, generates a voltage pulse proportional to the number of photons detected. Efficiency of detection is high in this method since the radiation is emitted within the detecting material itself. In particular, it is the **only way to detect weakly penetrating radiation** such as the beta emission from tritium. More generally, it is the chosen method to detect low level, loose surface contamination in the work place.

8.4 Neutron Detection

Since neutrons are neutral, they cannot be detected directly. Instead, detection relies primarily on absorption of neutrons in helium-3, lithium-6 or boron-10. As the neutrons collide with these materials, they generate ionized particles, either protons or alpha particles, which have a high energy and can be detected. A Wide Energy Neutron Detector (Wendi-2) is suitable for neutron detection.

8.5 Comparison of Detector Applications

In summary, the end window GM detector is the most versatile piece of monitoring equipment, however, its use is limited to materials, which can penetrate its window and be stopped by the detecting material. For example, the 18 keV beta from tritium (H-3) will not be able to penetrate the window at all, the 156 keV from Carbon-14 (C-14) will barely be detected, while high energy gamma photons may go through the tube without significant interaction with the gas. **It is not adequate for contamination checks**. Table 6 (following page) summarizes some relevant properties of various detectors and their applications.

Table 6: Application of radiation detectors

Detector	Radiation	Energy Range	Detection Efficiency
G-M Tube	Alpha	above 3.5 MeV	low
G-M Tube	Beta and Electrons	above 70 kev	moderate
G-M Tube	Gamma	above 6 kev	low - near 1%
Organic Scintillator: anthracene, stilbene, in plastics	Beta and Electrons	depends on detector casing	moderate
Inorganic Scintillator: ZnS(Ag)	Alpha	above 4 MeV	high
Inorganic Scintillator: NaI(Tl) (25 mm dia x 25 mm thick)	Gamma	above 40 kev	moderate
Inorganic Scintillator: NaI(Tl) (25 mm dia x 1 mm thick)	Gamma	between 10 - 40 kev	moderate
Liquid Scintillation	Alpha, Beta, Gamma	0 - Mev range	varies with radiation energy
Wide Energy Neutron Detector (Wendi-2)	Neutrons	Thermal (25 MeV) to 5 GeV range	

8.6 Monitor Maintenance

At SFU, we have two types of monitors: survey meters and contamination meters. Survey meters measure the dose rate or amount of dose to a person per unit time. The units of measurement are mR/hr or mSv/hr. A certified technician is required to calibrate Survey meters annually. Contamination monitors measure activity per unit time in units of cpm. Contamination meters are difficult to calibrate since the efficiency for detection of activity will vary with the energy of the radioisotope being measured. Contamination meters undergo an annual operational check carried out by the Radiation Safety staff. Several meters are sent to a CNSC certified technician for calibration for response to Cs-137. These calibrated monitors are identified by colored label tape on the handle and are strategically located at various sites across the campus.

Note: Battery checks should be performed on all monitors **prior to use** each time the monitor is turned on.

9. Contamination Checks

9.1 Monitoring Requirements for Sealed Sources

When using sealed sources, the radioactive work area must be assessed on a routine basis for contamination. It is preferable when working with gamma and X-ray emitters to leave the GM in the working area with the monitor on. Shielding shall be provided to ensure that workers are not exposed to radiation levels in excess of 25 µSvhr^{-1} (2.5 mRem hr^{-1}); in most cases, workers should be shielded such that fields do not exceed 2.5 µSv hr^{-1} (0.25 mRem hr^{-1}). Sealed sources with an activity greater than 50 MBq are checked twice annually for leakage by Radiation Safety staff (see **Appendix N:** Leak Testing Protocol)

9.2 Monitoring Reqirements for Open Sources

It is preferable when working with high energy beta, gamma or X-ray emitters to leave the contamination meter in the working area with the monitor on. In addition, routine swipe tests are required when using open sources. In particular, in authorized locations, swipe tests of the work area must be done at **minimum** on a **weekly basis**. Weeks during which work with radioactive open sources is carried out are to be noted on the yearly calendar included in the swipe test logbook. Users must relate the activity found on the swipe test to the criteria laid out in the University's radioisotope license. For information on the length of time required to produce results with the proper accuracy, see **Appendix O.**

Table 7: Allowable non-fixed contamination for Class A, B, and C isotopes

	Sample Isotopes	**Areas where unsealed nuclear substances are used or stored** (Bq cm^{-2})	**All other areas** (Bq cm^{-2})
CLASS A ISOTOPES long lived alpha emitters and daughters	Co-56, Cs-137, Co-60, Po-210, Na-22, Pu-239, U isotopes	3	0.3
CLASS B ISOTOPES long lived beta or gamma emitters	Sr-90, I-131	30	3
CLASS C ISOTOPES short lived beta or gamma emitters	C-14, Ca-45, Cl-36, Co-57, Cd-109, Fe-55, H-3, I-125, Ni-63, P-32, P-33 ,S-35	300	30

The amount of removable contamination permitted depends on the isotope in use, its half-life, and the nature of the emission and whether the area is one in which isotopes are used or stored or other areas.

Table 7 gives the allowable non-fixed contamination for Class A, Class B and Class C isotopes in areas where nuclear substances are used or stored and in all other areas. **Note that the area reported in the swipe test record shall not exceed 100 cm^2** (see also Table 12 for approximate surface area of common items.). A radiation field due to fixed contamination must not exceed 0.5 µSv/hr at a distance of 0.5 m. In the worst case scenario, an individual who spent an entire working day at a distance of 0.5 m from a source with a dose rate of 0.5 µSv/hr, would receive a yearly integrated dose of 2000 x 0.5 = 1000 µSv/year = 1 mSv/Year (assuming a 2000 hour yearly work load). That is, the individual would receive the maximum yearly allowable occupational dose.

9.3 Calculation of Maximum Permissible Contamination for Swipe Tests

This section describes how to convert the license criteria for allowable non-fixed contamination shown in Table 7 to practical units (cpm/cm^{-2}) taking into account the efficiency of the liquid scintillation counter shown in Table 8, and the efficiency of the swipe to remove non-fixed contamination. On the following page is a sample calculation, using C-14 as the isotope being measured, which shows how to derive maximum permissible contamination values for swipe tests from the license criteria and the liquid scintillation counter efficiency.

Table 8: Liquid scintillation counting efficiency for selected radioisotopes

Radioisotope	*Typical Efficiency*
H-3	50%
I-125	58%
Co-57	80%
Ni-63	85%
C-14, S-35	90%
I-131, Cd-109	95%
Pu-239	98%
P-32, P-33, Na-22, Co-60, Cs-137, Po-210, Ca-45, Cl-36	100%

For use of C-14 in areas of use or storage, the Maximum Permissible Contamination for Swipe Tests is 300 Bq cm^{-2}. Therefore, the criteria expressed in disintegrations per minute (dpm) is derived as follows:

$$300 \text{ Bq cm}^{-2} = 300 \text{ dps cm}^{-2} \text{ x } 60 \text{ s min}^{-1} = 18000 \text{ dpm cm}^{-2}$$

To obtain the criteria expressed in cpm (counts per minute) which is the quantity provided by the measuring instrument, the dpm cm^{-2} is multiplied by the detector efficiency and by the swipe efficiency, ie:

$$\text{cpm cm}^{-2} = (\text{dpm cm}^{-2}) \text{ x (LSC efficiency for particular isotope) x (swipe efficiency)}$$

Example of C-14:

LSC efficiency ≈90% (see Table 8 for LSC efficiency for selected radioisotopes); typically one assumes a 10% swipe efficiency. Then:

Allowable contamination = 18000 dpm cm^{-2}
≈ 18000 dpm cm^{-2} x 90% x 10% ≈ 1620 cpm cm^{-2}

Table 9 compiles the results of these calculations for selected isotopes used at SFU.

For ease, the numbers in Table 10 have been rounded off, erring on the side of caution, including the most restrictive case of a Class A radioisotope. These values, summarized in the last row of Table 9 represent at SFU the maximum allowed levels of removable surface contamination above which the surface is to be considered contaminated.

Table 9: Approximate Liquid Scintillation Counting readings corresponding to maximum permissible removable surface contamination for selected radioisotopes

	Typical Maximum net cpm cm^{-2} (Net cpm = Gross cpm – background)*	
Isotopes	**Areas of Use/Storage**	**Other Areas**
H-3	540	54
C-14	1620	162
Na-22, Cs-137, Co-60, U isotopes	18	1.8
P-32, P-33	1800	180
Co-57	180	18
I-125	1044	104
Pu-239	16	2
Sr-90, I-131	171	1.6

*The swipe efficiency is assumed to be 10%.

Based on the values determined in Table 9 and for ease of use, Radiation Safety has established the recommended values for maximum permissible removable contamination in Table 10.

Table 10: SFU Radiation Safety Recommendation for maximum permissible removable surface contamination

Maximum net cpm cm^{-2} (Net cpm = Gross cpm – background)		
All Isotopes	**Area of Use/Storage**	**All Other Areas**
	10	1

If contamination in excess of the values in Table 10 is found, the item should be decontaminated as soon as possible. If the floor or equipment in an area other than one where isotopes are used or stored, the equipment or area must be clearly delineated or marked to show radioactive contamination.

Following decontamination, items or areas are required to be re-swiped and the new swipe test values entered in the Swipe Test log or record. The Geiger counter is not an acceptable method of detecting contamination for these weekly checks: the Geiger counter should be used while handling radioactive materials and for daily contamination checks. Note that contaminated bench paper is to be discarded in its entirety; it is not acceptable to cut out only the contaminated areas.

For reference and to express the results of swipe checks into cpm/cm^2, Table 11 below gives approximate surface areas of common items used in a radioisotope laboratory.

Table 11: Approximate surface area of common items to estimate surface contamination from swipe test readings

Item	Area in cm^2	Area to use for calculations
Pipettor	50	10
1 floor tile	900	100
Large tongs	20	10
Large shield	2500	100
Small shield	900	100
‘Gel’ box and tray	900	100

9.4 Record Keeping of Swipe Tests

A **numerical** record of the results must be entered in the contamination log in the form of cpm per surface area swiped. It is not acceptable to record swipe test results as “background” or “no contamination found.” These records may not be discarded without permission of the CNSC. Weeks in which radioactive work with open sources is carried out are to be noted on the yearly calendar included in the weekly swipe test log.

9.5 Swipe Test Record Form

There are two options for this form: one records results in net cpm/cm^2 and the other in Bq/cm^2. See https://www.sfu.ca/srs/work-research-safety/research-safety/radiation-safety/specific-procedures.html to download forms or refer to **Appendix C**.

9.6 Contamination Control

To reduce the chances of contamination:

- Review the experimental protocol prior to using radioactive materials
- Streamline handling
- Remove unnecessary equipment from the radioactive area
- Use double containment (i.e. place radioactive materials in a secondary container)
- **Continuously monitor the work area, gloves and lab coats if feasible**
- When working with volatile radioisotopes, all handling of such material must be done in the fume hood

- Keep in mind that some radioisotopes may have volatile decomposition products, as is the case with S-35 methionine, which may require special handling procedures and/or working in the fume hood
- Wear gloves only during handling; contaminated gloves will contaminate anything else you touch

It is a policy at SFU that **one glove** may be worn, if necessary, **outside the lab when carrying hazardous materials.** However, caution is required to ensure that you use the non-gloved hand to open doors and other enclosures.

For contamination control, it is advised **not to wear lab coats outside labs** in hallways.

10. Minimization of Exposure

There are three basic principles to keep in mind when working with radiation in order to minimize one's exposure: time, distance, and shielding. These factors should be used for effective protection of users.

See https://www.sfu.ca/srs/work-research-safety/research-safety/radiation-safety/exposure-control.html for more information on exposure control.

10.1 Minimize Exposure Time

Experiments must be carefully planned in order to minimize the time of exposure. "Dry" runs in which no active materials are used should be performed to master the particular technique. Attention should be given to ensure that active stock solutions be accessed a minimum number of times. For instance, it may be more advantageous to withdraw one aliquot of 300 kBq from the main source and divide it further into three samples than to withdraw a 100 kBq aliquot from the same source on three separate occasions, risking exposure to the source each time.

10.2 Increase Distance from the Source

Increasing distance is one of the easiest and least expensive methods of minimizing exposure. It is also very effective, especially for alpha and beta radiation which have a short range in air. Although gamma and X-rays have longer ranges, exposure can still be greatly minimized by increasing body distance from the source.

The inverse square law expresses the relationship between source and point of interest:

$$\frac{I}{I_0} = \frac{D_0^2}{D^2}$$

Where I_o is the original intensity, D_o the original distance, I the "new" intensity D the new distance.

Example:

What is the intensity of radiation from a gamma source at 6 m if a reading taken at 0.5 m is 600 mR hr^{-1}?

In this example, I_o = 600 mR hr^{-1}, D_o = 0.6 m, and D = 6 m. Solving for I:

$$I = I_0 \times \frac{D_0^2}{D^2}$$

I = 6 mR hr^{-1}

This example assumes that the absorption through air is negligible.

Note: The **inverse-square law does not apply for low and medium energy beta emitters**. For example, you could measure the beta radiation field at one meter from 37 MBq of I-131 and note that it is 4 µGy hr^{-1}. Applying the inverse square law you would calculate 4 mGy hr^{-1} at 10 cm and 400 mGy hr^{-1} at 1 cm. The actual fields are more than a factor of ten greater than this. The inverse square law does not take into account the air absorption of low and medium energy beta emitting radioisotopes.

10.3 Use Shielding

Shielding shall be provided to ensure that workers are not exposed to radiation levels in excess of 25 µSv hr^{-1} (2.5 mRem hr^{-1}); in most cases, workers should be shielded such that fields do not exceed 2.5 µSv hr^{-1} (0.25 mRem hr^{-1}).

In any situation requiring shielding, consideration should be given to the 4-π (all directions) solid angle geometry of radioactive emission; this may necessitate shielding the back of a hood or bench area to protect individuals in adjoining rooms, or shielding the bench "floor" to reduce exposure to the lower torso and legs.

i. Gamma Emitters

For gamma emitters and X-rays the ideal absorber, because of its high density, is lead. Its major drawback is a low melting point, which in the case of fire, would leave the source exposed. Additionally, lead residue is toxic if ingested or inhaled. Other absorbers are concrete, steel, iron, depleted uranium and fan steel. The most commonly used material is lead and concrete. When working with **lead shielding**, it is important that the **bench be strong** enough to support the weight of the bricks and **gloves should be worn to prevent transfer of lead to the hands.**

ii. Beta Emitters

Beta emitters have limited range in air and in the majority of cases the glass container or the liquid itself will absorb most of the beta particles emitted. Higher energy beta emitters such as P-32 with an $E_{\beta max}$ of 1.7 MeV have a maximum range of 6 m in air. For these "hard" beta emitters shielding becomes essential.

When shielding against beta particles, "Bremsstrahlung" emissions must also be considered. Bremsstrahlung Radiation is produced during the interaction of electrons (beta particles) with the medium they traverse. Bremsstrahlung intensity and energy increases with the atomic number of the absorber material. For this reason, low-density materials such as Plexiglas are the ideal absorbers for high-energy beta particles; lead should only be used as a secondary shield for high-energy beta radiation. At SFU we expect P-32 users to do their major handling behind Plexiglas shields and to store their contaminated waste in Plexiglas containers with a lid.

See **Appendix D** for commonly used shielding at SFU.

11. Tracking Radioactive Materials

11.1 Receipt of Radioactive Materials

Tracking of radioactive materials on campus follows the 'cradle-to-grave' protocol. All materials must be accounted for from the moment they arrive on campus until they leave as waste or are transferred to another site.

All incoming items containing radioactive materials arrive at 'Science Receiving' and are **received by the Radiation Safety Technician (RST)**. At SFU, **only the RST** or **another TDG 7 trained and certified EHS staff member may receive radioactive shipments**. The procedure for receiving radioactive materials is as follows:

- Perform all manipulations wearing a lab coat and disposable gloves (PPE)
- If material is volatile, place the package in the fume hood. If the package contains high energy beta, gamma or X-ray emitters, place the package behind appropriate shielding before proceeding
- Swipe test the external surface of the package for contamination
- Check the package contents for possible damage and if damage is discovered, isolate the package to prevent contamination
- Swipe test the interior surfaces of the original package, the vial and the vial holder (pig), if present
- If contamination is found on the external packaging, consult the waste regulations to determine if packaging should be stored for decay or disposed; if no contamination is found on the outside and inside of the box, deface any radioactive materials print/sign on box
- If contamination is found on the vial or vial holder, decontaminate by spraying paper towels with cleaning solution (e.g. 'Count-Off') and wiping down the surfaces. Repeat the swipes. If contamination persists, repeat decontamination followed by swipe testing until the contamination levels fall within the levels recommended in Table 10; in case of **extensive contamination** discard as per protocol as **radioactive waste**; if inside of 'pig' is severely contaminated, but not the vial itself, replace the vial holding container
- Record swipe test results, batch number, purchase order number, volume or weight, activity, half-life, catalogue number, vendor, permit holder who ordered the material, destination room number, date ordered and reference date. Issue a unique identifying sticker and decal number for each item (e.g. open source vial, sealed source)
- Enter the item in the Radiation Safety Inventory Data Base
- Prepare an Inventory Sheet for the vial(s) , open source radioisotope, and deliver the vial(s) to the user

Upon delivery, if users notice any irregularities in the shipping documents, labeling, contamination on the outside of the package or a damaged package or package contents, contact the RST or the Program Manager, Ionizing Radiation with the details.

11.2 Inventory Control

An inventory record sheet accompanies each unsealed radioactive source. Isotope users are responsible for

- Maintaining an ongoing record of usage of each source
- Tracking each aliquot removed by weight or volume from the original vial, open source vial
- Estimating the activity delivered to each waste stream
- **Noting the date** on which the **empty source vial is returned to the Hot Lab**

Records of use must be noted on the inventory sheet and readily accessible for inspections and may not be discarded without prior approval from Radiation Safety staff. Refer to **Appendix E** for sample inventory sheets that follows. In the case of sealed sources, only an inventory number is issued.

11.3 Tracking Protocol

SFU's radioisotope tracking protocol is displayed in **Appendix L**.

12. Handling Radioactive Waste

The disposal of all radioactive waste is regulated by the CNSC, which specifies that a strict accounting be made of all radioactive waste generated. The CNSC has also determined the maximum amount of each radioisotope, expressed in **Exemption Quantities (EQ),** which may be released to the atmosphere, the municipal garbage, or the water system. These values are summarized below in Table 12.

Table 12: Accepted release limits for commonly used radioisotopes

Isotope	EQ (MBq)	Solids to Municipal Garbage (MBq/Kg)	Aqueous waste to Municipal Sewer System (MBq/year/building)	Gaseous waste to atmosphere (kBq/m^{3})
C-14	10	3.7	10,000	-
P-32	0.1	0.37	1	-
H-3	1000	37	1,000,000	37
I-125	1	0.037	100	-
P-33	100	1	10	-
S-35	100	0.37	1000	-
Co-57	1	0.37	1000	-

At SFU, the Radiation Safety Technician (RST) controls radioactive waste disposal.

In general, users are required to:

- Segregate radioactive waste by radioisotope
- Segregate waste by waste type (organic liquid, aqueous liquid, low level solid, high level solid, biosafety)
- Determine the amount of radioactivity of the waste, and package in **exempted quantities.** Each package must not exceed the EQ of the contained radioisotope.
- Label each waste container with a waste tag, noting waste type, isotope, radioactivity, room of origin, permit holder and date when facilitating handling and transfer to the Hot Lab
- Enter the identification number (ID#) of the waste tag on the inventory sheet to ensure tracking of any waste to its source vial
- Transfer suitably labeled and packaged wastes to the Hot Lab for further processing

Detailed protocols for waste analysis and handling can be found in **Appendix G**.

If the user is unable to package waste in exempt quantities, consult with the RST or Program Manager, Ionizing Radiation. Waste that is in excess of exemption quantities may be returned to the hot lab and stored for decay if the half-life of the material is less than 2 years. The length of storage required is in the range of 7 to 10 half-lives. After seven half-lives the activity of any radioisotope is reduced to less than 1% of its initial value. These **wastes must be monitored prior to disposal**. Waste containing materials with half-lives in excess of two years is currently stored on campus, but may have to be sent off-campus for disposal. It is important that only contaminated waste be sent to storage. Space is limited and should not be used to store trace contamination or uncontaminated waste for years.

All radioactive waste generated must be clearly labeled: radioisotope, approximate radioactivity, and room number of origin, date, and permit holder using tags provided. See Figure 4, Sample Radioactive Waste Tag.

Figure 4: Sample Radioactive Waste Tag

RADIOACTIVE

WASTE

I.D. # 5155
PERMIT HOLDER:
ROOM:
DATE:

- ☐ AQUEOUS LIQUID
- ☐ ORGANIC LIQUID
- ☐ LOW LEVEL SOLID
- ☐ HIGH LEVEL SOLID
- ☐ ANIMAL WASTE
- ☐ BIOHAZARD WASTE

ISOTOPE:
ACTIVITY:

13. Personal Monitoring Program

13.1 Personal Monitoring

i. External Monitoring

External Monitoring is accomplished using Optically Stimulated Luminescent (OSLs) badges, also called radiation badges or personal dosimeters. See **Appendix H** to determine if your work requires that you wear a badge. OSLs can be used to monitor the whole body potential exposure to stronger beta or gamma radiation. For the exposure to radiation of extremities, finger badges – Thermoluminescent Dosimeters (TLDs) are used. Since the personal dosimeters (pds) are worn for 3–4 months at a time prior for evaluation of exposure, there can be a substantial time delay in assessing exposures. If immediate information is required, as is the case in work undertaken in high radiation fields, a direct readout, pencil dosimeter will be issued.

See https://www.sfu.ca/srs/work-research-safety/research-safety/radiation-safety/exposure-control.html for radiation badge application.

ii. Internal Monitoring

Internal monitoring is necessary when volatile radioisotopes are used or accidentally ingested. This form of monitoring is referred to as "bioassay". Useful methods of bioassay are organ counting, urine assay, saliva swabs, serum and fecal counts.

iii. Thyroid Bioassay

Individuals using radioiodines may be required to undergo thyroid bioassays according to the criteria in Table 13 below. Individuals requiring bioassay are required to report to the RST in the Hot Lab or the Program Manager, Ionizing Radiation Safety to undergo a thyroid check prior to initiating work with radioiodines and then again during the interval 24 hours – five days following an experiment involving an iodination. Thyroid bioassays must be undertaken using the Sodium Iodide (NaI) probe in the Hot Lab (B7249) specifically calibrated for this purpose. Results showing intake in excess of 1 kBq (60,000 cpm) must be reported to the RSO for investigation. The counting system dedicated to thyroid measurement of iodine intake is preset to give a Minimum Detectable Amount (MDA) of 300 Bq(+/- 20%).

See **Appendix R** for thyroid screening quality control verification and screening measurements.

Table 13: Bioassay requirements for radioiodine use

Location of Use	Activity of Radioiodine Used within a 24-Hour Period and Requiring Bioassay (MBq)
Open room	2 MBq
Fume hood	200 MBq
Glove box	20,000 MBq
Spill of volatile radio-iodines	2 MBq
External radioiodine contamination detected	Any amount

13.2 Personal Exposure Records

Radiation Safety staff maintain all records of internal and external monitoring in conjunction with the National Dosimetry Service in Ottawa. A cumulative record of exposure for each individual wearing a PD is maintained in Ottawa over the work period of the user. These records are open to anyone wishing to see them. Contact the RST for further information.

13.3 Nuclear Energy Workers (NEWs)

A nuclear energy worker (NEW) is defined as:

"A person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public"
(Nuclear Safety and Control Act)

The Program Manager, Ionizing Radiation Safety, makes the NEW classification. According to the Radiation Protection Regulations, every licensee shall inform each nuclear energy worker, in writing:

1. a) That he or she is a nuclear energy worker;
   b) Of the risks associated with radiation to which the worker may be exposed in the course of his or her work, including for women, the risks associated with the exposure of embryos and fetuses to radiation;
   c) Of the applicable effective dose limits and equivalent dose limits
   d) Of the worker's radiation dose levels.

2. The licensee shall also inform each female nuclear energy worker, in writing of the rights and obligations of a pregnant NEW and the effective dose limits.
3. Radiation Safety staff must obtain from each NEW written acknowledgement that the NEW has received the above information (see **Appendix I** for Notification of Nuclear Energy Worker Status form).

The RSO has to at least once per year inform NEWs under their jurisdiction of their annual dose in writing.
Note: Students and researchers at SFU working with typical radioisotopes (ie. H3, C14, P32, etc.) do not fall under the classification of a NEW.

13.4 Maximum Permissible Doses

The maximum permissible occupational doses are listed in **Appendix H**.

Exceeded dose limit

When a licensee becomes aware of a received or committed radiation dose to a person, an organ or tissue may have been exceeded an applicable dose limit, the licensee must:

- Immediately notify the person and the Commission of the dose
- Require the person to leave any work that is likely to add to the dose if the person may have or has received a diose that exceeds a dose limit for a NEW
- Conduct an investigation to determine the extend of the dose and to establish the causes of the exposure
- Identify and take any action required to prevent the occurrence of a similar incident
- Within 21 days after becoming aware that the dose limit has been exceeded, report to the Commission the results of the investigation or the progress

13.5 Pregnancy and Breastfeeding while Working with Radioisotopes

As of 2021, the CNSC REGDOC 2.7.1 has been updated, and pregnant NEWs are no longer required to disclose a pregnancy in writing to the RSO, however, it is strongly recommended. The following guidance on radiation risk and accommodating pregnant and breastfeeding NEWs is provided:

- Risks to embryos and fetuses from internal and external radiation, including stage of pregnancy and nuclear substances of concern (e.g. radioiodines, tritiated water, carbon-14, sulfur-35, phosphorous-32, as well as isotopes of calcium and strontium)
- Risks to breastfed infants from nuclear substances concentrated in breast milk
- Additional guidance on assessing the dose to a breastfed infant for commonly used nuclear substances can be found in the CNSC REGDOC 2.7.2, vol.1

The effective dose to a pregnant nuclear energy worker (NEW) must not exceed 4 mSv for the balance of the pregnancy. The dose to a NEW who is breast-feeding must be such that the dose to the breast-fed infant does not exceed the whole body dose to a member of the general public, that is, 1 mSv/year. Upon disclosure of a pregnancy, the SFU RSO will provide additional monitoring devices, and in addition to the regulations of the CNSC, the regulations of the provincial WorkSafeBC include some aspects of radioactive work. In particular, WorkSafeBC regulations stipulate that:

- The effective radiation dose to a pregnant woman using radioisotopes is limited to 4 mSv for the duration of her pregnancy or the dose limit specified for pregnant workers under the *Nuclear Safety and Control Act* (Canada)
- When requested by a pregnant worker or by a worker intending to conceive a child, the employer must make counselling available with respect to the reproductive hazards associated with exposure to ionizing radiation

Upon disclosure of a pregnancy in writing to the RSO, the following services will be provided by Radiation Safety Staff:

- Consultation for the reassignment of work duties in order to minimize exposure, and promote the ALARA principle
- Additional radiation monitoring devices

The disclosure of a pregnancy will remain private and confidential.

13.6 Traveling with your Radiation Badge

In general, radiation badges should not leave the work site (i.e. SFU campus). However, in some cases, because of research demands, it may be necessary to travel by air with your badge. If this is the case, it is recommended that you hand carry your badge through airport security. Leaving your badge in your checked or carry-on luggage will likely result in an exposure from the X-rays or CAT scanners used for security purposes and interfere with the measure of your occupational exposure to radiation.

EH&S provides 'film exposure protection' pouches on loan for air travel which can be used to protect radiation badges (personal dosimeters) from radiation exposure caused by airport scanning. Additionally, EH&S will provide a control badge, which should not to be used for occupational purposes during the trip. EH&S can provide you with a letter of explanation should you need to justify this practice

14. Internal Review of the Radiation Safety Program

Compliance with internal and external regulations is confirmed through annual inspections carried out by Radiation Safety staff. Sample inspection sheets for a laboratory using Open Sources (i.e. unsealed nuclear substances) and Sealed Sources can be found in **Appendix J** – Internal Inspection.

If items of non-compliance are observed, confirmation should be obtained that the items are corrected, either immediately at the time of inspection or for more complicated items of non-compliance, through a re-inspection.

Compliance with internal and external regulations is governed by SFU Policy R20.04 and more specifically by the measures to promote the safe use of radioactive materials.

15. Decommissioning of Radioisotope Laboratories

In order to decommission a designated radioactive laboratory or enclosure such as refrigerator or freezer, the following conditions must be satisfied:

- Print and fill-out **Appendix F** – The radioactive clearance checklist
- Comprehensive swipe tests of the area or the enclosure must show that non-fixed contamination meets the license criteria shown in Table 10 and Table 11 of Section IX Contamination Checks
- If fixed contamination exists, the release of the room or the enclosure must be approved by the CNSC or a person authorized by the CNSC
- All nuclear substances and radioactive devices must be transferred to another approved area
- All radioactive signs must be removed or defaced
- A copy of the swipe tests must be forwarded to the Radiation Safety Officer (RSO). Upon approval from the RSO, the room may be returned to general use
- The copy of the **swipe tests** must be kept on file by **Radiation Safety staff**

16. Incidents, Accidents, and Emergencies

16.1 Spill Kit

Refer to **Appendix K** – Radioisotope Spill Response Procedure for a list of spill kit contents

Note: A laminated copy of the Radioisotope Spill Response procedure form should be stored in your spill kit.

16.2 Spill Management

Refer to **Appendix K** – Radioisotope Spill Response Procedure for spill management

16.3 Reporting Requirements for Spills and Contamination Events

i. Reporting to the Radiation Safety Staff

Report all spills, incidents, contamination events or suspected contamination events and near misses involving nuclear substances or radiation emitting devices to the Radiation Safety contacts using the twenty-four hour contact information on page 53. An online incident report should be completed at https://www.sfu.ca/srs/contact/report/report-incident.html

ii. Reporting to the CNSC

The following occurrences require immediate reporting to the CNSC by Radiation Safety staff:

- Any spills or incidents that involve more than 100 Equivalent Quantities of radioactive material or the release of volatile material
- An extremity skin dose above 50 mSv for a NEW or an extremity skin dose above 5 mSv for a non-NEW
- Unauthorized release of radioactive material into the environment
- Attempt or actual breach of security
- Act of sabotage
- Failure or degradation of a system, which is likely to contribute adversely to health or safety of people, a threat to the environment, or maintenance of security.

17. Security of Radioactive Materials

To guard against thefts and/or losses of radioactive materials, all radioactive sources must be **secured from unauthorized access.** As a rule, rooms where radioactive materials are stored or used must be kept locked at all times unless an authorized user is present in the room. Additionally, when radioisotopes are in use, users are required to ensure that the source vial or sealed source is secured during the user's absence.

i. Sealed Sources

In the case of sealed sources or equipment containing a radioactive source, the room shall be kept **locked** when unattended by an approved radioisotope user.

ii. Open Sources

Open sources shall be stored in a **locked** refrigerator, freezer or other suitable container, secured by a padlock. Padlocks are available from the Radiation Safety Technician. Should the storage container require modification to accommodate a padlock, arrangements can be made through Facilities Services via a work order for such modification. Note that in the case of the compact "bar" refrigerators, the refrigerator must be bolted to the floor to prevent removal. Facilities Services can also complete this work.

iii. Non-Approved Users

Non-approved users may not be given access to radioactive sources. More generally, unfamiliar individuals loitering around research laboratories should be challenged as to their identity or their presence reported to Campus Security.

iv. Thefts or Losses of Radionuclides

The Radiation Safety Officer must report thefts or losses of radioisotopes immediately to the CNSC. Consequently, if theft or loss is suspected, or if a pattern of loss of radioisotope is observed, contact Radiation Safety staff immediately. See also section 16.3 for reporting requirements.

18. Appendices

Application for internal radioisotope permit

Please submit the permit application at least 2 months prior to commencing work

1. **Name of permit holder:**
2. **Department**:
3. **Office Telephone**:
4. **Cellphone (in case of emergency):**
5. **Lab Telephone**:
6. **E-mail Address**:
7. **Names(s) of individual(s), other than permit holder, who will be handling radioactive materials:**
8. **University location(s) where radioactive materials will be handled and stored (list room numbers):**
9. **Radioisotopes required:**

Open sources (solid or liquid)	Sealed sources	Maximum activity to be stored in the licensed location(s)	Maximum activity to be used during an experiment
1.			
2.			
3.			
4.			

Application for internal radioisotope permit

10. List below the type of instruments intended for use for contamination monitoring (e.g. Liquid Scintillation counter, Geiger-Mueller counter):

11. Brief statement of intended use of radioisotopes:

12. The applicant agrees that the statements contained herein and the radioisotopes outlined in this application shall only be used as authorized by the SFU Radiation Safety Committee and in accordance with SFU's Radiation Safety Policy R 20.04.

Name: Date:

Signature:

Appendix B

Importing nuclear materials

Special considerations need to be given to items which fall under the internationa nuclear non-proliferation treaty which requre a special import permit.

Please contact the Radiation Safety Officer if you wish to import nuclear materials from outside of Canada, for the folllowing items:

- Uranium
- Thorium (>0.05% by weight)
- Plutonium
- Radium 223
- Tritium (if H3:H > 1:1000)
- Some sources of Radium 226
- Some sources of Neptunium 237
- Fermium 257
- Neutron Generator
- Some sources of Americium 241, 243
- Polonium 208, 209, 210
- Actinium 225, 227
- Gadolinium 148

Appendix C

Radiation safety contamination check record

Radiation Safety Contamination check record

Isotope_____________ Room#______________ Year ______________

Date	Swipe test location	Wipe area (max 100 cm^2)	Net cpm (gross – blank)	Bq/cm^2	Bq/cm^2 (after Cleaning)	Initials

$$Bq/cm^2 = \frac{\textit{Net cpm}}{6 \times \textit{Smear size}(cm^2)}$$

must be < 3 Bq/cm^2 in working areas
< 0.3 Bq/cm^2 in any other area.

Radiation safety contamination check record

Radiation Safety Contamination check record

Isotope____________ Room#_____________ Year _____________

Date	Swipe test location	Wipe area (max 100 cm^2)	Net cpm (gross – blank)	cpm/cm^2	cpm/cm^2 (after Cleaning)	Initials

$$cpm/cm2 = \frac{\textit{Net cpm}}{\textit{Smear size}(cm^2)}$$

must be $< 10\ cpm/cm^2$ in working areas,
$< 1\ cpm/cm^2$ in any other area.

Appendix D

Shielding requirements

Table 1: What types of shielding should be used for some commonly used radionuclides at SFU

Item	Area in cm^2
Radionuclide*	**Shielding material**
H-3 (tritium)	none
C-14 S-35 Ca-45	Plexiglas, if detectable with the GM
P-32 Sr-90	Plexiglas
I-125	Lead Sheeting
Co-60 Na-22 Cs137	Lead Bricks

*If the radioisotope you are using is not listed on this table and you would like to know which shielding to use, Please contact the Hot Lab at 778.782.3506 or 2-3506

Appendix E

Sample inventory sheet

Simon Fraser University
Radioisotope Usage

Code:	Form:	Permit Holder:	Bat.Number:
Date:	Ref. Date:	Date Ord'd:	PO Number:
Vendor:	Half-life:	Amount(MBq):	Cat.Number:
Room:		Volume(µl):	Location:

Date vial sent to Hotlab___________________

SOURCE USAGE (UNIT =)					**WASTE BREAKDOWN** (UNIT=)									**PRODUCT INFORMATION**	
DATE	USER	AMOUNT USED	AMOUNT REMAINING	PROCEDURE	HIGH LEVEL SOLID	ID	LOW LEVEL SOLID	ID	AQUEOUS LIQUID	ID	ORGANIC LIQUID	ID	OTHER	STORAGE LOCATION	AMOUNT STORED

REMARKS:

Appendix E

Sample inventory sheet

SIMON FRASER UNIVERSITY
Radioisotope Usage

Code: P32-123
Date: 01/01/2019
Vendor: NEN
Room: SSC B1234

Form: ATP
Ref. Date: 01/10/2019
Half-life: 14.3d

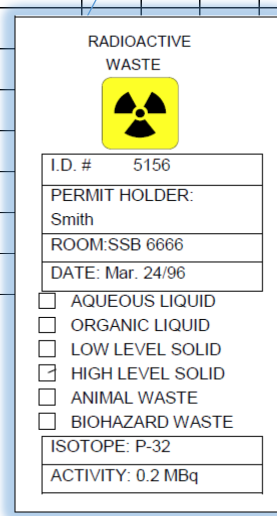
Permit Holder: Smith
Date Ord'd: 12/31/2018
Amount(MBq): 37 MBq
Volume(µl): 100 uL

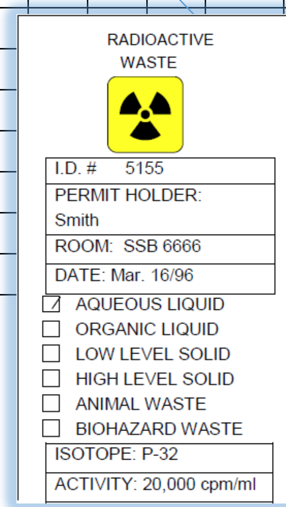
Bat.Number: 900000
PO Number: SX123456
Cat.Number: ABC1234
Location: Freezer

Date vial sent to Hotlab 04/25/2019

SOURCE USAGE (UNIT = uL) *1					WASTE BREAKDOWN (UNIT= %)									PRODUCT INFORMATION	
DATE	USER	AMOUNT USED	AMOUNT RE-MAINING	PROCEDURE	HIGH LEVEL SOLID	ID	LOW LEVEL SOLID	ID	AQUEOUS LIQUID	ID	ORGANIC LIQUID	ID	OTHER	STORAGE LOCATION	AMOUNT STORED
01/01/2019	RST	0	37 MBq 100 uL	Delivery	–	–	–	–	–	–	–	–	–	– –	– – –
01/02/2019	Your Name	3 uL	97 uL	Sequencing	30 %	5156	2 %	312	68%	5155	–	–	–	– –	– – –

REMARKS: Concentration activity = 0.37 MBq/uL





Appendix E

Inventory sheet documentation

As a condition of the license at SFU, all isotopes must be accounted for from the moment they arrive at Science Receiving until they decay to background levels or are disposed of as waste. All shipments of radioactivity are received in the Hot Lab and issued a unique identifying number and an inventory sheet which allows tracking of radioisotope usage for a particular source. As a user of radioisotopes, it is your responsibility to document your usage, storage, transfer, generation of waste, and disposal of radioisotopes.

Sometimes, this process may seem unnecessarily arbitrary or cumbersome. But aside from the legal requirement, the process is ultimately to ensure accountability and your safety.

Enclosed are some completed sample inventory sheets for four separate scenarios as well as some completed waste tags used for labeling waste containers:

Scenario I - Routine Use of a P-32 labeled isotope for sequencing

Scenario II - Use of C-14 for labeling and storage of product for later analysis

Scenario III - Transfer of radioisotope to an individual in another room on a different permit.

These scenarios cover the most frequent cases encountered. It may be that none of these fit exactly your situation. Please do not hesitate to contact Radiation Safety if you are not sure how this form applies to your particular use situation.

Appendix E

Sample waste tag

RADIOACTIVE WASTE

I.D. #	5155
PERMIT HOLDER: Smith	
ROOM: SSB 6666	
DATE: Mar. 16/96	

- [x] AQUEOUS LIQUID
- [ ] ORGANIC LIQUID
- [ ] LOW LEVEL SOLID
- [ ] HIGH LEVEL SOLID
- [ ] ANIMAL WASTE
- [ ] BIOHAZARD WASTE

ISOTOPE: P-32
ACTIVITY: 20,000 cpm/ml

RADIOACTIVE WASTE

I.D. #	5156
PERMIT HOLDER: Smith	
ROOM:SSB 6666	
DATE: Mar. 24/96	

- [ ] AQUEOUS LIQUID
- [ ] ORGANIC LIQUID
- [ ] LOW LEVEL SOLID
- [x] HIGH LEVEL SOLID
- [ ] ANIMAL WASTE
- [ ] BIOHAZARD WASTE

ISOTOPE: P-32
ACTIVITY: 0.2 MBq

Scenario I – How to determine % Waste

The only waste that we can easily measure with accuracy is the aqueous waste. We know that the original concentration of the source material is 37 MBq/100 µl. If we removed 2 µl from the source vial for our experiment, then the amount used in the first experiment was:

37 MBq/100 µl x 2 µl = 0.74 MBq.

To measure the activity of the aqueous waste, we remove a 1 ml solution and count it on the scintillation counter. In this case, a 1 ml solution had an activity of 20,000 counts per minute (20,000 cpm).

The total volume of aqueous waste is 1.5 litres.

1. Assuming that the liquid scintillation counting is 100% efficient, then the total activity present in the aqueous waste is:

1.50 l x 20,000 cpm/ml = 3 x 10^7 cpm

= 3 x 10^7 dpm

2. Convert dpm to dps:

3 x 10^7 dpm/ 60 per second = 5 x 10^5 dps

3. Convert dps to Bq:

5 x 10^5 dps = 5 x 10^5 Bq = 0.5 MBq

Therefore, the % activity in the aqueous waste is:

0.5 MBq/0.74 MBq x 100% = 68%.

4. Knowing accurately the activity of the aqueous waste and approximating the low level waste as ~2% allows us to estimate the activity present in the high level solid as:

100% - 68% - 2% = 30%.

5. The activity in the bag of high level solid waste is

~30% x 0.74 MBq = 0.222 MBq

Appendix E

Inventory sheet documentation

SOURCE USAGE (UNIT =). : Any convenient unit is acceptable (e.g. mCi, kBq, ml, µl, etc…). However, if units other than "activity" are used, indicate the specific activity under **REMARKS**; for example, if **UNIT** = ml, then indicate "Source is *xx* MBq/ml."

DATE, USER: Any entry in a row must be date and the person entering the data must be identifiable.

AMOUNT USED/REMAINING: This refers to the quantity used (remaining) from (in) the source vial, expressed in the **UNI**T chosen above.

PROCEDURE: Enter a generic term for the procedure performed (e.g. iodination); if necessary, under **REMARKS**, present a more precise description of the **PROCEDURE**.

WASTE BREAKDOWN (UNIT =): **UNIT** may be activity or percent (%) of **AMOUNT USED**.

HIGH LEVEL, LOW LEVEL, AQUEOUS, ORGANIC: Consult Table VIII - Handling of Radioactive Waste to decide which headings are applicable

ID: This refers to the unique number which is located on the waste tag. Waste tags are available from the Hot Lab.

OTHER: Enter any waste amount not identified in the previous columns, e.g carcass, *xx* MBq.

STORAGE LOCATION, AMOUNT STORED: Entries under these two items refer to the case where the **PROCEDURE** generates new radioactive products which are stored in a **STORAGE LOCATION** for further use.

RADIOACTIVE WASTE TAG: All bags and containers of waste which are transferred to the Hot Lab must be labelled with a Radioactive Waste Tag. Note that the actual amount or activity of isotope, not percentage of waste, must be recorded in the box marked: "**ACTIVITY**.

SFU SAFETY & RISK SERVICES | ENVIRONMENTAL HEALTH & SAFETY

Appendix E

Inventory sheet example 1

Scenario I: P-32 Usage

SIMON FRASER UNIVERSITY

Code: P-32-9999	Form: dCTP	Permit Holder: Sen	Bat.Number: 90000
Date: Mar 12, 2016	Ref. Date: Mar 14, 2016	Date Ord'd: Mar 6, 2016	PO Number: S246810
Room: SSB 6666	Half-life: 14.3 days	Amount (MBq): 37 MBq	Cat.Number: AA1001
Location: fridge	Volume (µl):100 µL		

DATE VIAL SENT TO HOTLAB *Sept 30/2016*

SOURCE USAGE (UNIT = µL ①)					WASTE BREAKDOWN (UNIT= % ②)									NEW PRODUCT INFORMATION	
DATE	USER	AMOUNT USED	AMOUNT REMAINING	PROCEDURE	HIGH LEVEL SOLID ID		LOW LEVEL SOLID ID		AQUEOUS LIQUID ID		ORGANIC LIQUID ID		OTHER	STORAGE LOCATION	AMOUNT STORED
Mar 12/16	Alina	0	37 MBq 100 µL	delivery	---	---	---	---			---		---		
Mar 14/16	Yousef	2 µL	98 µL	sequencing	30%	---	2%	---	68%	---			0		
Mar 16/16	Henry	2 µL	96 µL	sequencing	30%	128 ③	2%	---	68%	---			0		
Mar 21/16	Karen	3 µL	93 µL	sequencing	30%	---	2%	---	68%	---			0		
Mar 24/16	Andrea	3 µL	90 µL	sequencing	30%	5156 ④	2%	312⑤	68%	5155 ⑥			0		

REMARKS: Concentration Activity = 0.37 MBq/ µL

Scenario I - Isotope is removed twice a week for two weeks.

① The units chosen for usage are µL. The concentration activity is noted under "Remarks."

② The unit chosen for waste is % of amount used.

③ At the end of week 1, the high level solid waste is packaged, labeled with a waste tag numbered #128. The waste is transferred to the Hot Lab, SSC-B7249.

④ At the end of two weeks, the high level solid waste is again packaged, labeled with a waste tag numbered numbered #5166, and sent to the Hot Lab.

⑤ The low level solid waste is labeled with waste tag #312.

⑥ The aqueous waste container is labeled with waste tag #5155. The contents are sampled and measured by liquid scintillation counting and the activity noted on the waste tag, before transferring it to SSC-B7249.

SFU SAFETY & RISK SERVICES | ENVIRONMENTAL HEALTH & SAFETY

Appendix E

Inventory sheet example 2

Scenario II - Labeling and storage of product for later analysis

SIMON FRASER UNIVERSITY

Code: C-14-1234	Form: benzopyrene	Permit Holder: Kennedy	Bat.Number: 99999
Date: Mar 14/16	Ref. Date: Mar 28, 2016	Date Ord'd: Mar 1, 2016	PO Number: S111111
Vendor: NEN	Half-life: 5730 years	Amount (MBq): 37 MBq	Cat.Number: CFA 417
Room: B 7777	Volume (µl): 1000	Location: freezer	

DATE VIAL SENT TO HOTLAB *Sept 30/2016*

SOURCE USAGE (UNIT = µCi ①)					**WASTE BREAKDOWN (UNIT= µCi ②)**									**NEW PRODUCT INFORMATION**	
DATE	USER	AMOUNT USED	AMOUNT REMAINING	PROCEDURE	HIGH LEVEL SOLID ID		LOW SOLID	LEVEL ID	AQUEOUS LIQUID ID		ORGANIC LIQUID ID		OTHER	STORAGE LOCATION	AMOUNT STORED
Mar 14/16	Alina	0	37 MBq	delivery	---		---		---	---	---		---	---	----
Mar 16/16	Blair	1 µCi	999	injection of trout	-----	---	---	---	---		---	---		freezer Alcan 108 ③	0.20 µCi, ④ heart & liver
					-----	---	---	---	-.--		---	---	0.50 µCi ⑥	freezer, Alcan 108 ⑤	0.30 µCi tissue homogenate
Jun16/16	Blair	---	---	analysis of frozen tissue.					0.15 µCi ⑦	24	0.15 µCi	25			

REMARKS:

① The unit chosen for usage is µCi.
② The unit chosen for waste is µCi.
③, ④ The researcher wants to save the fish heart and liver, containing 0.20 µCi, in the freezer, for a later study.
⑤Approximately 0.30 µCi muscle and skin is homogenized in saline and stored in the freezer for later analysis.
⑥The rest of the fish carcass is wrapped and labelled with a waste tag, noting the total weight of the carcass and the activity present. The carcass is then taken to SSC-B7249, after prior arrangement, for storage.
⑦ On June 16, the frozen tissue homogenate prepared in March, is analyzed, generating 0.15 µCi aqueous waste and 0.15 µCi organic waste, in containers labeled #24 and #25, respectively.

SFU SAFETY & RISK SERVICES | ENVIRONMENTAL HEALTH & SAFETY

Appendix E

Inventory sheet example 3

Scenario III - Transfer of radioisotope vial and contents to another permit

SIMON FRASER UNIVERSITY

Code: H-3-5000	Form: thymidine	Permit Holder: Young	Bat.Number: H65432
Date: Mar. 22, 2016	Ref. Date: Apr 22, 2016	Date Ord'd: Mar 1, 2016	PO Number: S22222
Vendor: ICN	Half-life: 12.3 y	Amount (MBq): 9.25 MBq	Cat.Number: H678
Room: SSB 5000	Volume (µL): 250 µL	Location: freezer	

DATE VIAL SENT TO HOTLAB *Sept 30/2016*

SOURCE USAGE (UNIT = MBq)					**WASTE BREAKDOWN (UNIT= MBq)**									**NEW PRODUCT INFORMATION**	
DATE	USER	AMOUNT USED	AMOUNT REMAINING	PROCEDURE	HIGH LEVEL SOLID ID		LOW LEVEL SOLID ID		AQUEOUS LIQUID ID		ORGANIC LIQUID ID		OTHER	STORAGE LOCATION	AMOUNT STORED
Mar 22/16	Alina	0	9.25	delivery	----	----	----	----	----	----	----	----	-----	----	-----
Mar 25/16	Kurt	0.37	8.88	labeling cells	0.26	266 ①	trace		---	---- ----	0.11	**②183**	---	---	---
Mar 27/16	Ian	0.74	8.14	transfer to Lee lab, BLU 10763 ③	---	---	---	---	---	---	---	---	---		---
Apr 4/16	Ian	0.37	7.77	labeling cells	0.26		trace		---	----	0.11		---	---	---

Remarks:

①After using 0.37 MBq, the high level solid waste is packaged and labelled with waste tag #266

② The organic waste is packaged and labelled with waste tag #183 and sampled using liquid scintillation counting to determine the activity, which is also entered on the waste tag..

③ The vial and remaining contents are given to another lab; this is indicated as a transfer. The new location of the vial is noted on the inventory sheet. The inventory sheet stays with the vial, until the vial is returned to the Hot Lab.

Appendix F

Radioactive Clearance Checklist

Before a radioactive permit can be closed, the lab/room(s) must be cleared of all radoactive materials. The radioactive permit holder is responsible for ensuring that all items described on this checklist are completed.

If a permit holder intends to discontinue work with radioactive materials and close a radioactive permit, the Radiation Safety Officer (Tel: 2-3633) or the Radiation Safety Technician (Tel:2-3506) needs to be contacted to schedule a Radioactive Clearance inspection (email: radsafety-info@sfu.ca)

Please complete the Laboratory Clearance Checklist.

Radioisotope Permit Number	
Permit to be	☐ Closed ☐ Modified
Permit holder (Principle Investigator	
Room Number(s)	

Compliance Item	Completed		
	Yes	No	Comments
All radioactive material has been transferred to the Hot Lab and the transfer has been noted on the researchers inventory sheet			
All radioactive waste (including sharps containers) and designated low level, foot operated radioactive waste containers have been returned to the Hot Lab			
All bench tops and work surfaces have been decontaminated and swipe-tested for contamination; swipe-test records have been provided to Radiation Safety			
Swipe records with clearly noted identification of swiped areas have to be provided to Radiation Safety staff			
Refrigerators and freezers have been decontaminated and cleaned, inventory sheets removed and placed into a lab-binder for record keeping in the location.			
All floors have been decontaminated and cleaned			

This form must be provided at the time of final inspection by Radiation Safety staff. All safety signage must remain in place until the inspection is complete.

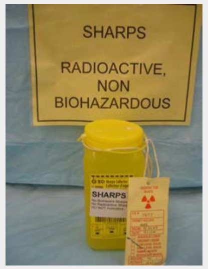
Permit holder signature: _______________________________________ Date: ______________________

Radiation Safety signature_______________________________________ Date: ______________________

Radioactive waste handling

Designation	Examples	Criteria	Containment	Disposal procedure
SOLID - Low Level 	Gloves Paper Toweling Empty Scintillation Vials	<u>For H-3, C-14, P-33, S-35:</u> possibly contaminated but not likely <u>For P-32 and I-125:</u> <100 cpm measured with the Geiger-Counter	Specially marked foot operated garbage cans lined with plastic bags	Remove plastic bag, complete waste tag and tie to bag, record waste tag number on inventory sheet(s) and transfer bag to B7249 Hot Lab
SOLID - High Level 	Pipette Tips Eppendorf Holders Contaminated Bench Paper	<u>For H-3, C-14, P-33, S-35:</u> Anything which has been in intimate contact with radioisotope <u>For P-32 and I-125:</u> >100 cpm above background measured with the G.M.	<u>For H-3, C-14, P-33, S-35:</u> Beaker lined with plastic bag <u>For P-32 and I-125:</u> Shielded box (plexiglass or lead) lined with a plastic bag	Remove plastic bag, complete waste tag and tie to bag, record waste tag number on inventory sheet(s) and transfer bag to B7249 Hot Lab. In the case of P-32 and I-125, transport with appropriate shielding

Radioactive waste handling

Designation	Examples	Criteria	Containment	Disposal procedure
SOLID - Radioactive Sharps 	Syringes Needles Scalpel Blades Razor Blades		Radioactive Sharps Container available from the Bioscience Hot Lab	Label with waste tag, record activity on inventory sheet and take to B7249 Hot Lab
SOLID – Glass	Pasteur pipettes Test Tubes Broken		Wide mouthed plastic jugs with secured lid, or by prior arrangement, a plastic lined box, or THICK plastic bags	Label with waste tag, record activity on inventory sheet and take to B7249 Hot Lab
Solid - Animal Materials 	Animal Excrement Carcasses Animal Tissue or Tissue Digests	H-3< 37 MBq/kg C-14< 3.7 MBq/kg P-33< 1 MBq/kg S-35< 0.37 MBq/kg P-32< 0.37 MBq/kg I-125< 0.037 MBq/kg	Store in freezer until disposal is arranged with Hot Lab Technician	Wrap in plastic bag, tag, record activity on inventory sheet, and take to B7249 Hot Lab with prior arrangement (tel: 3506)

Radioactive waste handling

Designation	Examples	Criteria	Containment	Disposal procedure
AQUEOUS LIQUID - Low Level (water based) 	Sequencing Buffer Water Soluble Materials	H-3< 1,000 cpm/ml C-14< 200 cpm/ml P-32< 200 cpm/ml	Empty plastic bottle or jug with secure lid. NO GLASS. Note: shielding may be required for P-32 and I-125 waste	Remove 1 ml sample of liquid and count on Liquid Scintillation Counter. Record activity on tag and on inventory sheet. Place bottle in a thick, clear, plastic bag, and seal. Transfer to B7249 Hot Lab.
AQUEOUS LIQUID - High Level (water based) 	Reaction products which are water soluble	H-3 >1,000 cpm/ ml C-14 >200 cpm/ml P-32 >200 dpm/ml P-33all aqueous wast e S-35all aqueous wast e I-125all aqueous waste	Empty plastic bottle or jug with secure lid. NO GLASS. Note: Shielding may be required for P-32 and I-125 waste	Remove 1 ml sample of liquid and count on Liquid Scintillation Counter. Record activity on tag and on inventory sheet. Place bottle in a thick, clear, plastic bag, and seal. Transfer to B7249 Hot Lab.

Radioactive waste handling

Designation	Examples	Criteria	Containment	Disposal procedure
ORGANIC LIQUID  	Scintillation Liquid Solvent based reaction materials Chlorinated materials Toxic materials Water insoluble materials		Empty plastic bottle or jug with secure lid. NO GLASS. Note: Shielding may be required for P-32 and I-125 waste	Remove 1 ml sample of liquid and count on Liquid Scintillation Counter. Record activity on tag and on inventory sheet. Place bottle in a thick, clear, plastic bag, and seal. Transfer to B7249 Hot Lab.
RADIOACTIVE and BIOHAZARDOUS	Radioactive blood, bacteria Viruses, primate body fluids	Biohazard Classification Risk Group 1 or 2.	Contact Occupational Health and Safety at 5728 for procedures before packaging waste.	Do NOT autoclave radioactive-biohazardous materials. Label container with waste tag and transfer to B7249 Hot Lab.
RADIOACTIVE and BIOHAZARDOUS SHARPS  	Radioactive and biohazardous needles Syringes Scalpel Blades Razor blades	Biohazard Classification Risk Group 1 or 2.	Designated Red Biohazardous Sharps Container available from Science Stores. Contact Occupational Health and Safety at 5728 for procedures before packaging waste.	Do NOT autoclave radioactive- biohazardous materials. Label container with waste tag and transfer to B7249 Hot Lab.

Appendix H

Personal monitoring program

Table 1: External Monitoring

Emission	Whole Body OSL	Extremity TLD
Alpha	Not Required	Not Required
Beta	Not Required	Required if activity > 50 MBq
Gamma	Required for any activity	Not Required
Neutron	Required for any activity, **in addition to a neutron badge**	Not Required
X-ray Generating Devices	Required	Not Required

Table 2: Maximum Permissible Occupational Doses

Target organ or Tissue	Nuclear Energy Workers* (mSv/year)	General Public (mSv/year)
Whole body	50 or <100 over 5 years 20**	1
Skin	500	50
Lens of eye	50	15
Hands and feet	500	50

*The effective dose to a pregnant nuclear energy worker (NEW) must not exceed 4mSv for the balance of the pregnancy (the dose limit specified for pregnant workers under the *Nuclear Safety and Control Act* – Canada)

** https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-07-noise-vibration- radiation-and-temperature#SectionNumber:7.17

All information obtained from the Canadian Nuclear Safety Commission: INFO-0827 at https://nuclearsafety.gc.ca/pubs_catalogue/uploads/INFO-0827-Introduction-to-Dosimetry-e.pdf

Appendix H

Pencil Dosimeter Monitoring Form

Name	VERIFY Dosimeter ID #	Pre-exposure (mR)	Post-exposure (mR)	Initials
Alina Tepes	Y		n/a – prep for loan	AT
Name	**VERIFY Dosimeter ID #**	**Pre-exposure (mR)**	**Post-exposure (mR)**	**Initials**
Alina Tepes	Y		n/a – prep for loan	AT

Appendix I

Notification of nuclear energy worker status

A Nuclear Energy Worker (NEW) is a person who might receive an occupational radiation dose greater than 1 mSv/year. The Radiation Safety staff make the NEW classification. According to the Radiation Protection Regulations, every licensee shall inform each nuclear energy worker, in writing,

1. a) that he or she is a nuclear energy worker;
   b) Of the risks associated with radiation to which the worker may be exposed in the course of his or her work, including for women, the risks associated with the exposure of embryos and fetuses to radiation;
   c) Of the applicable effective dose limits and equivalent dose limits
   d) Of the worker's radiation dose levels.

2. The licensee shall also inform each female nuclear energy worker, in writing of the rights and obligations of a pregnant NEW and the effective dose limits.

3. Every licensee shall obtain from each nuclear who is informed of the above written acknowledgment that the worker has received the information.

I have received information regarding the risks associated with the radiation to which I am exposed, of the dose limits and of my radiation dose level.

Name: ______________________________ Date: ______________________________

Signature: ______________________________

Appendix J

Internal inspections

Verification of Compliance is accomplished through internal inspections. These are conducted at least annually. All inspections are done with the iAuditor program on the iPad. The content of the inspection checklists for sealed and open sources can be found on the following pages.

The laboratory is notified of the inspection results through email. In cases where compliance is compromised, the laboratory may be re-inspected to verify compliance.

Appendix J

Pre-inspection checklist

- ☐ Ensure that a current permit is posted on the door of every room which you are authorized to use and that the information (i.e., users and radioisotopes) is kept up-to-date.
- ☐ Ensure that a radiation sign is posted at the entry of all authorized rooms.
- ☐ Ensure that the laboratory hazardous door sign is updated with the radiation safety staff emergency contact numbers.
- ☐ Ensure that the CNSC room classification poster are posted inside the lab where unsealed sources are used. (Note: no posters are required for labs where sealed sources are used exclusively).
- ☐ Ensure swipe tests records are kept in an easily accessible location within the lab.
- ☐ Maintain accurate record of inventory sheets (See Special Procedures – Waste Handling for more information).
- ☐ Ensure work space is covered with bench paper, and is delineated with 'radioactive' tape.
- ☐ Ensure no contamination is present within the lab by checking equipment and areas through conducting swipe tests and/or area surveying.
- ☐ Lock your lab doors when the lab is vacant. Ensure that the radioactive source vial and radioactive samples (not waste) are stored in a locked refrigerator, freezer or other storage location.
- ☐ No food or drinks are allowed in the lab
- ☐ Label refrigerators, freezers, cabinets and other enclosures in which radioisotopes are stored with isotope contents and activity. Place inventory sheets on storage location.
- ☐ Ensure all radioactive items are labeled with radiation warning tape.
- ☐ Ensure non-radioactive items are not labelled with radioactive labels.

Appendix J

Unsealed (open) source inspection checklist

Permit Number:	**Permit Holder:**	**Room #:**
Lab Signage	**Inspection**	**Re-inspection (if applicable)**
1. Is the current permit posted on the door?	Yes☐ No☐	Yes☐ No☐
2. Are the users listed on the permit?	Yes☐ No☐	Yes☐ No☐
3. Are the following signs posted?		
a. Name and 24 hours emergency contact	Yes☐ No☐	Yes☐ No☐
b. "Danger Radiation" Warning sign on the door	Yes☐ No☐	Yes☐ No☐
c. Hazardous Lab Door Sign	Yes☐ No☐	Yes☐ No☐
d. CNSC classification poster in work area	Yes☐ No☐	Yes☐ No☐
e. "In use" signs in radioactive areas	Yes☐ No☐	Yes☐ No☐
4. Are radioactive equipment, glassware and samples used for radioactive work labelled as radioactive?	Yes☐ No☐	Yes☐ No☐
5. Is high level waste labelled as radioactive with isotope name?	Yes☐ No☐	Yes☐ No☐
6. Are any non-radioactive items labelled as radioactive?	Yes☐ No☐	Yes☐ No☐
Lab Practice		
7. Are hot benches covered with bench paper?	Yes☐ No☐	Yes☐ No☐
8. Are emergency clean-up supplies available?	Yes☐ No☐	Yes☐ No☐
a. Location?		
9. Is there a low level radioactive waste bin?	Yes☐ No☐	Yes☐ No☐
10. Is excess liquid and/or solid waste transferred to the Hot Lab (SSC B7249)?	Yes☐ No☐	Yes☐ No☐
11. Any coffee cups or food items in lab?	Yes☐ No☐	Yes☐ No☐
12. Are radioisotopes secured with combination lock on the storage container?	Yes☐ No☐	Yes☐ No☐
13. All radioactive items are decontaminated and decontamination verified with wipe tests before returning equipment/glassware to general use?	Yes☐ No☐	Yes☐ No☐
14. Is a GM counter (survey meter) readily available?	Yes☐ No☐ N/A☐	Yes☐ No☐ N/A☐
a. Is the survey meter functioning properly?	Yes☐ No☐ N/A☐	Yes☐ No☐ N/A☐

Appendix J

Unsealed (open) source inspection checklist

b. Has it been recently calibrated?	Yes☐ No☐ N/A☐	Yes☐ No☐ N/A☐
15. Are the chairs suitable for work with radioisotopes?	Yes☐ No☐	Yes☐ No☐
16. Do users monitor their hands and clothes after radioactive work?	Yes☐ No☐ N/A☐	Yes☐ No☐ N/A☐
Documentation		
17. Is there an inventory of isotopes in the refrigerator/storage enclosure on the refrigerator/enclosure door?	Yes☐ No☐	Yes☐ No☐
18. Are weekly swipe tests being conducted?	Yes☐ No☐	Yes☐ No☐
19. Is current inventory of usage maintained?	Yes☐ No☐	Yes☐ No☐
20. Is the waste path documented on the inventory sheet?	Yes☐ No☐	Yes☐ No☐
a. Is the Vial returned to hot lab section filled out on the inventory sheet once the vial is returned as waste?	Yes☐ No☐	Yes☐ No☐
21. Is the waste transferred to the Hot Lab (SSC B7249) and given an identifying level which is noted on the inventory sheet?	Yes☐ No☐	Yes☐ No☐
Dosimetry		
22. Do users know where/how to obtain a dosimeter?	Yes☐ No☐	Yes☐ No☐
23. Do users know where exposure results are available?	Yes☐ No☐	Yes☐ No☐
24. Do pregnant users know of the pregnancy-specific dosimetry requirements?	Yes☐ No☐ N/A☐	Yes☐ No☐ N/A☐
25. If iodine is being used, are bioassays conducted as required?	Yes☐ No☐ N/A☐	Yes☐ No☐ N/A☐
Wipe Test Results		
Location of wipe testing: 1. 2. 3. 4. 5.	***Swipe Test Results:*** 1. 2. 3. 4. 5.	
After wipe testing was conducted? Do any areas need to be decontaminated? If so, which ones.		

Appendix J

Unsealed (open) source inspection checklist

Other Comments

Note**:** Please keep a copy all documentation in the laboratory, indefinitely. No documentation shall be discarded of without prior permission from the Canadian Nuclear Safety Commission.

Name: **Date**:

Signature: ____

Radioisotope spill response procedure

Overview

Accidental releases of radiological material can present an immediate hazard to those in the area of the spill. Because of the long half-life of some radioisotopes and the penetrating power of ionizing radiation, a spill that isn't properly decontaminated can continue to present a hazard to those in the area for many years past the initial incident. It is of utmost important to immediately report any spill to EHS to request guidance and assistance to ensure any immediate and long-term risks are mitigated.

Before beginning work with any radiological material, be sure you know how you will detect it. For example, you will not necessarily be able to detect Tritium using a hand-held Geiger-Mueller counter. In the event of a spill, you would have to depend on wipe tests and liquid scintillation counting to locate, delineate, and confirm complete decontamination.

Depending on the severity of the spill and radiological properties of the material spilled (e.g., energy, alpha, beta, or gamma emmiter), shielding may be required to protect yourself during clean up. If the spill is large, reduce your exposure time by taking shifts with lab mates and EHS staff.

In the case of a radioactive spill, you are required to contact the Radiation Safety staff immediately.

Radiation Safety contact information

	SFU Local	Cell
Director, Research and Laboratory Safety	2-7265	(604) 512-7238
Radiation Safety Officer	2-3633	(604) 551-5692
Radiation Safety Technician	2-3506	(604) 365-3440

Radioisotope spill kit contents

All of the items listed below are available at SFU Science Stores. It is recommended to purchase a largess enough plastic bucket that all of the spill kit contents will fit inside for storage. This allows for quick response to a spill. Check the contents and condition of your spill kit once a month.

- ☐ Radioisotope spill response procedures (this document)
- ☐ Plastic bucket
- ☐ Alcohol swipes
- ☐ Garbage bags
- ☐ Heavy polyethylene bags to be used as shoe covers, or 'footsies'
- ☐ Electrical or duct tape for securing plastic bags as shoe covers
- ☐ Scintillation vials
- ☐ Flagging tape
- ☐ Paper towels
- ☐ "Caution – Radioactive Materials" warning signs
- ☐ Count-Off spray (or other suitable decontaminant)
- ☐ Diapers and spill pads
- ☐ Marking pens
- ☐ Protective gloves (nitrile, latex, vinyl, or neoprene)

Appendix K

Radioisotope spill response procedure

Call for help

Information

1. If you are in immediate physical danger, leave the area and call 911.
2. Inform people in the area that a spill has occurred. Keep them away from the contaminated area.
3. Cover the spill with absorbent material to prevent the spread of contamination.
4. Call co-workers, lab supervisor, and Radiation Safety staff for assistance. You MUST call Radiation Safety staff, even if the spill occurs after hours.

Minor spills

5. Check hands, clothing, and shoes for contamination. Replace any contaminated clothing and decontaminate skin as required to minimize exposure before proceeding to spill cleanup.
6. Wear protective clothing and disposable gloves. Clean up the spill using absorbent paper and place it in a plastic bag for transfer to a labelled waste container.
7. Avoid spreading contamination. Work from the outside of the spill towards the center.
8. Wipe test or survey for residual contamination as appropriate. Repeat decontamination, if necessary, until reported counts do not exceed background.
9. Check hands, clothing, and shoes for contamination once again.
10. Record spill details and contamination monitoring results. Adjust inventory and waste records appropriately.

Major spills

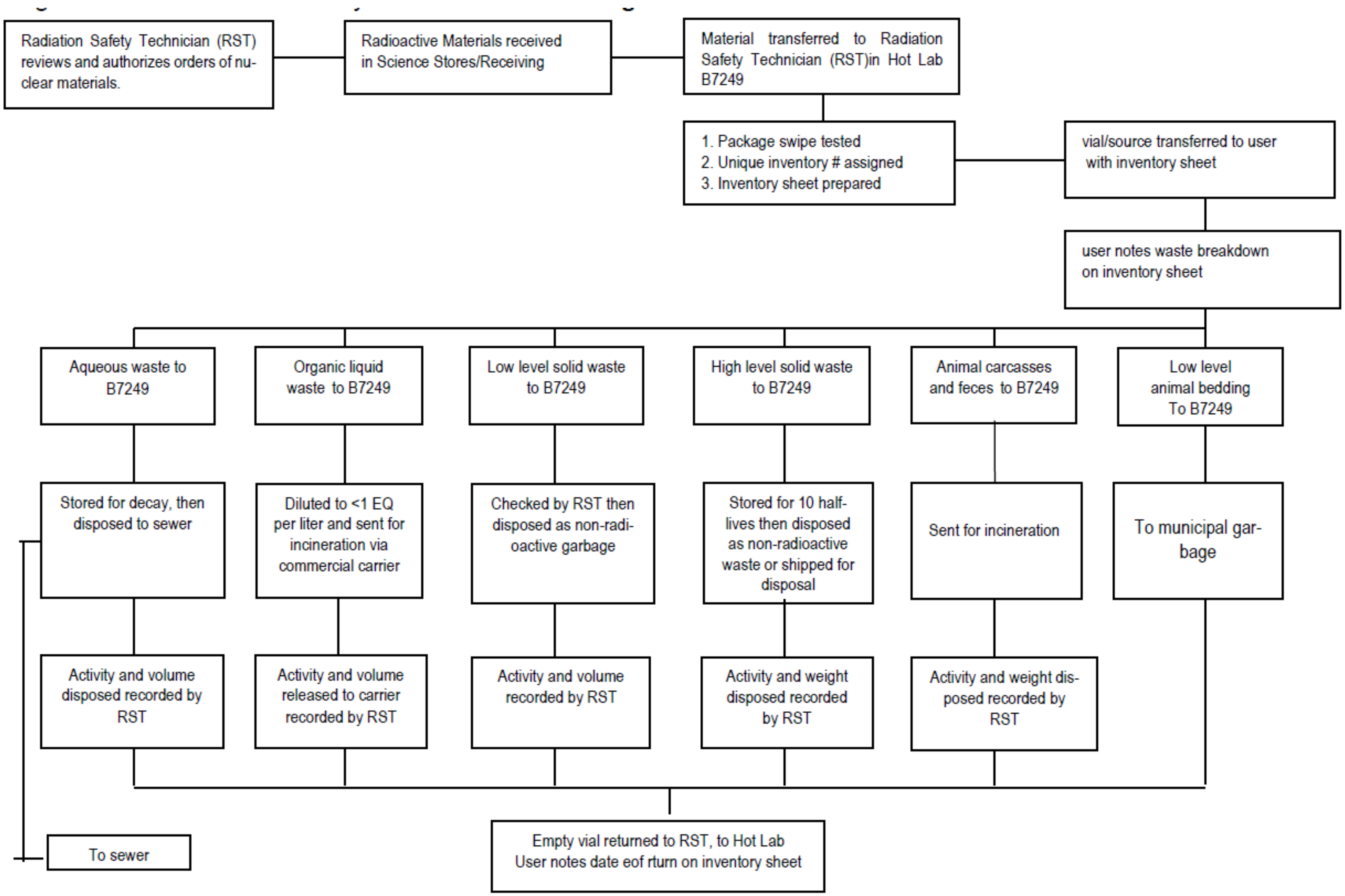
5. Clear the area. Persons not involved in the spill should leave the immediate area. Limit the movement of all personnel who may be contaminated until they are monitored.
6. If the spill occurs in a laboratory, leave the fume hood running to minimize the release of volatile nuclear substances to adjacent rooms and hallways.
7. Close off and secure the spill area to prevent entry. Post warning signs.
8. Notify the Radiation Safety Officer and EHS immediately.
9. The Radiation Safety Officer or designate will direct personnel decontamination and will decide about decay or cleanup operations.
10. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap.
11. Follow the above procedures for minor spills or proceed in accordance with authorized procedure.
12. Record the names of all persons involved in the spill. Note the details of any personal contamination.
13. If required, the Radiation Safety Officer or designate will arrange for any necessary bioassay measurements.

Reporting

14. Submit an incident report at www.sfu.ca/srs/report.
15. In the event of a major spill, the Radiation Safety Officer must notify the CNSC immediately and submit a full report within 21 days.

Appendix L

Radioisotope tracking protocol



Appendix M

Record keeping

Records to be maintained by Radiation Safety Staff	Records to be maintained by users
• Leak resting results • Record of decommissioned labs • Inventory of sources • Record of swipe tests • Record of waste disposal • Record of transferred sources • Record of source(s) transport • Personal exposure reports • List of Nuclear Energy Workers (NEWs) • Record of monitor calibrations • List of approved users • List of approved rooms and laboratory classification • List of user training • Record of incidents and accidents • Record of spills • Record of inspections	• Inventory sheets • Record of swipe tests

Note: No records may be disposed of without 90 day prior written notification of the CNSC.

Appendix N

Leak testing protocol for sealed sources

Radiation Safety staff undertake both leak test sampling and measuring for sealed sources. As a result, the measuring and sampling certificates are combined. Leak testing is provided solely as an "in house" service for Simon Fraser University. The Radiation Safety Technician, who is familiar with radiation safety principles, carries out the leak test sampling and measuring the operation of the Liquid Scintillation Counter and the requirements of the Canadian Nuclear Safety Commission for leak test sampling and measuring. The Radiation Protection Officer monitors results. Sampling and Measuring Procedures for the SFU Leak Testing Program are detailed below.

Sealed sources of activity greater than 50 MBq are leak tested. For sources which are continually in storage, the frequency of sampling and measuring is every 24 months. For sources in a device, the frequency of sampling and measuring is every 12 months. All other sources must be sampled and measured every 6 months. If the leakage from any source exceeds 200 Bq or 50 Bq of radon in 24 hours, the source must immediately be taken out of service and the CNSC notified within 24 hours. The Radiation Safety staff maintain leak test results. The leak sampling and measuring form is shown in Fig. A3-1.

Leak Test Sampling

1) Sampling Method:

The source or source housing is swiped with a commercially available, pre-packaged, alcohol moistened towelette (approximately 7 x 3 cm^2).

2) Types of Sources:

There are three types of sealed sources requiring wipe test procedures:

- The inner column (removed from nuclear gauge by cert. consultant, UniVert Tech Inc.) in which the source moves is wiped.
- Electron capture detectors in 2 gas chromatographs (Chemistry, REM): as described in the manufacturer's manual.
- In cases where the manual is not available, the detector port is swiped.

3) Handling of Swipes:

Following the wipe test, the wipes are placed in empty, labeled, 10 ml scintillation vials. The labeled vials containing the wipes are taken to SSC-B7249, the Hot Lab, for counting on one of the Liquid Scintillation Counters.

Leak Test Measuring

1) Preparation of wipes for activity measurement

Five ml of scintillation cocktail is added to each scintillation vial and the wipes are counted for two minutes on the Liquid Scintillation Counter. A blank sample, containing only scintillation fluid, is also counted for two minutes to establish background. All samples are counted on a wide-open window.

2) Activity measurement

Wipes are counted on one Liquid Scintillation Counters (LSC) located in SSC-B7249 and maintained by the Radiation Safety Technician. However, if required, there are also three other LSC research instruments

Leak testing protocol for sealed sources

available from various departments at SFU. Manuals for the LSC are available in SSC-B7249, Hot Lab and from the owners of the “other” LSC.

Equipment Calibration

The LSCs are calibrated monthly as per the instructions in the manufacturer’s manual with an unquenched, H-3 standard provided by the manufacturer. The efficiency is checked twice-monthly using unquenched, sealed standards of H-3, C-14, and a blank, supplied by the LSC manufacturer. Additionally, Radiation Safety at SFU participates in the annual C-14 and H-3 intercomparison study carried out by the Radiation Protection Bureau to verify reproducibility and accuracy. Previous intercomparison results attest that we can reliably detect 50 Bq of H-3 and 20 Bq of C-14. Detection efficiencies for the various isotopes for which leak tests are performed are conservatively taken as one-half the manufacturer’s values for the isotopes of interest. The method for calculating the expected MDA (Minimum Detectable Amount) is shown below.

Calculation of the Minimum Detectable Activity (MDA)

The MDA may be estimated using first Eq. (A6-8) from Appendix VI:

$$cpm_{Net}^{(\text{minimum})} = \frac{1}{2 \times \Delta t \times \left(\frac{\%err}{100}\right)^2} \left(1 + \sqrt{1 + 8 \times \Delta t \times cpm_{Bkg} \times \left(\frac{\%err}{100}\right)^2}\right)$$

where *%err* is the desired percent error on the result, Δt the duration of counting in minutes and cpm_{Bkg} the background count rate. Then the MDA in Bq can be obtained knowing the efficiency of the detector:

MDA (in Bq) = $cpm^{minimum}$ / (60 x efficiency)

Sample calculation:
Let *%err* = 5%, cpm_{Bkg} = 30 cpm, efficiency = 50% and Δt = 2 min.

$cpm^{minimum} = [1 + (1 + 8x10^{-4} \text{ x } 5^2 \text{ x } 30 \text{ x } 2)^{1/2}]/(2x10^{-4} \text{ x } 5^2 \text{ x } 2) = 248$ cpm

Finally, MDA = 248/(60 x 0.5) = 8.3 $\pm$ 0.4

Appendix O

Counting statistics

Essential Equations

All of what follows can be derived from two equations:

1) For *M* radioactive decay events (*ie*. *M* counts), the standard deviation is $\sqrt{M}$, in other words, the observed number of counts is:

$$\boxed{M \pm \sqrt{M}} \tag{1}$$

2) For a sum (or a difference), the absolute errors add up in quadrature, *ie*

$$\boxed{Err^2(a \pm b) = Err^2(a) + Err^2(b)} \tag{2}$$

Applying these two principles to a sample for which one measures *T* counts (Total counts) and *B* counts for the background in the same time interval Δt, *N* the net counts due to the sample is:

$$N = T - B \tag{3}$$

Then the standard deviation on *N*:

$$Err^2 N = Err^2 T + Err^2 B = T + B \tag{4}$$

or

$$Err(N) = \sqrt{T + B} \tag{5}$$

or expressed as relative error (in three different ways)

$$\%err(N) = \frac{Err(N)}{N} \times 100 = \frac{\sqrt{T+B}}{T-B} \times 100 = \frac{\sqrt{N+2B}}{N} \times 100 = \sqrt{\frac{(S+1)}{B(S-1)^2}} \times 100 \tag{6a}$$

where $S = \frac{T}{B}$ (6b)

Note that Eqs. (5) and (6) give the value of *one* standard deviation, or 67% confidence level interval. In many disciplines, the error reported is the 95% confidence level, which corresponds to *two* standard deviations. For this matter, it is this last quantity which is reported as % error in the output of Liquid Scintillation Counters.

The quantity *S* in Eqs. (6a) and (b) is related to the so-called signal-to-noise ratio; it describes by how much the sample count “sticks out” of the noise (the background), If $S = 1$ (*ie*., $T = B$), there is no signal. If $S >> 1$ ($T >> B$), there is plenty of signal and life is easy. A problem arises when $S > 1$ while $S \approx 1$. In this case, given that there are experimental uncertainties attached to the values of *T*, *B* and consequently of *S*, one may be faced with the question: is really $S > 1$ and if so, by how much? In other words, does my sample contain significant activity?

Meaning of the Two Standard Deviations (or 95% Confidence)

Reporting an experimental result with its 95% conf. level assumes that the particular measurement obeys a normal distribution which in turn means that if the experiment were to be repeated, there is a 95% chance that the new result would agree with the previous result within the quoted interval (or to state it as pollsters like to do it: the result is considered accurate within the quoted interval 19 times out of 20).

EXAMPLE OF RADIOACTIVE COUNTING.

If one collects 100 counts in a given time interval, the 95% conf. level is $2\text{x}100^{1/2} = 20$.

If one were to recount for the same duration the same sample over and over, 95% of the measurements (19 out of 20) would fall in the interval 80 – 120 counts (after appropriate correction for decay if the half-life is “short”).

For how long should I count?

For how long should I count to get the net cpm (net = gross – blank) of my sample within a predetermined percent error?

This question arises mostly for low activity samples. It is totally related to the question: is this cpm significantly higher than my background, or is there really some activity in this particular sample? High activity samples (> 1000 cpm), since they stand out of the background, do not present a problem in general.

From Eq. (6b), $S = \frac{T}{B} = \frac{cpm_{Gross}}{cpm_{Bkg}}$. Let *%err* be the desired percent standard deviation.

Then, the minimum counting time $\Delta t_{\min}$ to get net *cpm* of sample within *%err* is obtained by rearranging Eq. (6a):

$$\Delta t_{\min} = \frac{1}{cpm_{Bkg}} \frac{S+1}{\left(\frac{\%err}{100}\right)^2 (S-1)^2} \qquad (7)$$

Example:

After a quick count (say, 2 min per sample), the following is obtained: *Bkg* = 21 cpm and *Gross* = 34 cpm for the sample. Under these conditions, the percent error on these two pieces of data is respectively 15%

Counting statistics

and 12% (one standard deviation). This means that *Bkg* = 21 ± 3 cpm and *Gross* = 34 ± 4 cpm. The net *cpm* is then:

Net = *Gross* – *Bkg* = 34 – 21 = 13 cpm

and the error on *Net* , using elementary error propagation calculation of Eq. 5,

$$Err_{Net} = \sqrt{Err_{Gross}^2 + Err_{Bkg}^2} = \sqrt{3^2 + 4^2} = 5$$

i.e., *Net* = 13 ± 5 cpm (±38% standard deviation) or *Net* = 13 ± 10 (with 95% conf. level!), meaning that I can be 95% confident that *Net* is anywhere between 4 and 22 cpm.

If I want to know the net *cpm* with a standard deviation of 10% (ie, *cpm* ± 20% with 95% conf. level), using Eq. (7) above, the minimum counting time is calculated as ≈33 min. One can verify that for such a length of time, the results would be (using the same cpm values, and the 95% conf. interval):

Bkg = 21 ± 1.6 cpm (8% error) and *Gross* = 34 ± 2.1 cpm (6% error)

Then again:

Net = *Gross* – *Bkg* = 34 – 21 = 13 cpm and

$$Err_{Net} = \sqrt{Err_{Gross}^2 + Err_{Bkg}^2} = \sqrt{2.1^2 + 1.6^2} = 2.6$$

i.e., *Net* = 13.0 ± 2.6 cpm (± 20%), Now I can say with a 95% confidence level that my *Net* is between 10.4 and 15.6 cpm.

Minimum Detectable Activitiy

For a given counting time duration, how low a net cpm can I measure with a given percent error?

For example. I routinely count my samples for two minutes; what is the lowest net cpm I can trust accepting a 20% standard deviation on this value.

This is called sometimes the minimum detectable activity (MDA), for a given counting duration and a given expected error.

The formula to use is a rearrangement of equation (7) after solving for net cpm^{min}:

$$cpm_{Net}^{(\text{minimum})} \equiv MDA = \frac{1}{2 \times \Delta t \times \left(\frac{\%err}{100}\right)^2}\left(1 + \sqrt{1 + 8 \times \Delta t \times cpm_{Bkg} \times \left(\frac{\%err}{100}\right)^2}\right) \qquad (8)$$

where Δ*t* is the counting time duration in minutes, and %*err* the desired percent standard deviation.

Appendix O

Counting statistics

Example:

I count my swipe test samples for 1 min. To decide whether some surface contamination is present I must be able to detect reliably (± 20%) 100 cpm. Is a 1 min count sufficient?

One must determine the Bkg cpm, then use formula (8) above with ⍰*t* = 1 min and *%err* = 20. Let set *Bkg* = 20 cpm (typical value). One gets *MDA* = 130 cpm, a bit on the tight side. 1.5 min counting duration would be ideal.

Appendix P

Laboratory design requirements

The Canadian Nuclear Safety Commission provides recommendations for the design of Nuclear Substance Laboratories in document *GD-52 Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms*. The guide describes finishing of floor and wall surfaces, plumbing, ventilation, and other design features. The full document is available online from the CNSC website. In general:

- all surfaces (floors, walls, countertops, interior of fume hoods) should be smooth, and covered with an impervious, washable finish; any joints in the surface material must be sealed
- a separate hand washing sink and a wash-up/disposal sink will be provided
- An emergency eye-wash station will be provided in the room or in close proximity to the room.
- If volatile materials or materials that may generate aerosols or gases are being used, the room will be at negative pressure with the surrounding area (unless the room will be used as a clean or sterile room). Air flow will always be from the area of low radiation.
- General laboratories will have a minimum of 6 air changes per hour.
- Air vented through the fume hood will be vented without recirculation.
- Fume hoods will be located away from areas of air currents or turbulence (high traffic areas, doors, operable windows, air supply diffusers).
- Fume hoods will not be located adjacent to a single means of access to an exit, due to possible volatility of the fume hood contents.
- The face velocity of the fume hood will be at a minimum of 0.5 m/s.
- Each fume hood will have a continuous monitoring device for proper functioning of the hood. An alarm, either visual or audible, will be present to indicate reduced air flow.
- Provisions will be in place to ensure the fume hood remains functional if a routine automatic after-hours shutdown system is in place.
- Fume hoods will not contain filters. (If filtration will be required because nuclear substances will be released regularly through the fume hood exhaust or because biohazards are present, then detailed information about the filtration including filter monitoring and exchanges will be supplied.)
- Food and drink preparation, use, and storage areas will not be present in the room unless required as part of a nuclear medicine procedure.
- Office and study space will not be located near radioactive work areas.
- Rooms will have sufficient counter and floor space to allow people to work safely. (In general, allow at least 3 square meters of free floor space for each worker.)

Appendix Q

Mandatory Checklist for LSC Users

- ☐ Use the designated vials and lids
- ☐ Ensure lids are in-place and secured
- ☐ Ensure adequate liquid scintillation cocktail is added
- ☐ Do not contaminate the outside of the vials with the liquid scintillation cocktail, as it will damage the LSC
- ☐ To identify samples, write on top of the lids (note: do not write on the side of the vials as it will alter the light output)
- ☐ Do not operate the LSC with gloves on, as cross-contamination may occur.
- ☐ Maintain records of each LSC run. A **logbook** is provided in each LSC room for this purpose.
- ☐ Before using this equipment, all LSC users must be adequately trained in the safe use and operation of the LSC.

Appendix Q

Liquid Scintillation Counter (LSC) LOGBOOK

Date	Name	User Number	Rack Number	Number of Vials	Vials Removed	Supervisor

Appendix Q

Liquid scintillation counting

Introduction

The process by which radioactive decay energy is converted to visible light and measured in an organic liquid environment is called LIQUID SCINTILLATION COUNTING (LSC). In Liquid Scintillation Counting, the amount of light produced is proportional to the amount of radiation present in the sample and the energy of the light produced is proportional to the energy of the radiation that is present in the sample. This makes LSC a very convenient tool to measure radioactivity.

The Scintillation Process

The radioactive sample to be measured is combined with a scintillation cocktail. Scintillation cocktail is a mixture of an organic solvents; an emulsifier which ensures proper mixing of aqueous samples in the organic solvents; and a fluorophore, a substance which has the capability of fluorescing when excited by the radioactive substance. The light that is produced from the excitation of the cocktail by the radioactivity is directed to the photomultiplier tubes, which then convert the light into a measurable electrical pulse (see Figure 1). The amplitude of the pulse is proportional to the amount of light that has reached the photomultiplier tubes. Therefore, the pulse height at the output of the tubes is proportional to the energy of the radioactive sample. In order to discriminate between true radioactive decay events and the electrical background noise of the photomultiplier tubes, LS counters have a *coincidence gate* which allows measurement only of those events which occur simultaneously at both photomultiplier tubes.

The pulses from the photomultiplier tubes are analyzed, converted to digital form, and stored in the appropriate channel of a multichannel analyzer, corresponding to the radiation energy (Figure 2). This ability to sort the pulses detected according to their amplitude allows discrimination between emissions of different energies. For example, three commonly used isotopes ^{3}H, ^{14}C, and ^{32}P have beta energies of 18.3, 156 and 1,710 keV respectively. By setting windows judiciously, it is possible to specify which energy range is to be measured.

Appendix Q

Liquid scintillation counting

Figure 1: A block diagram of a scintillation counter

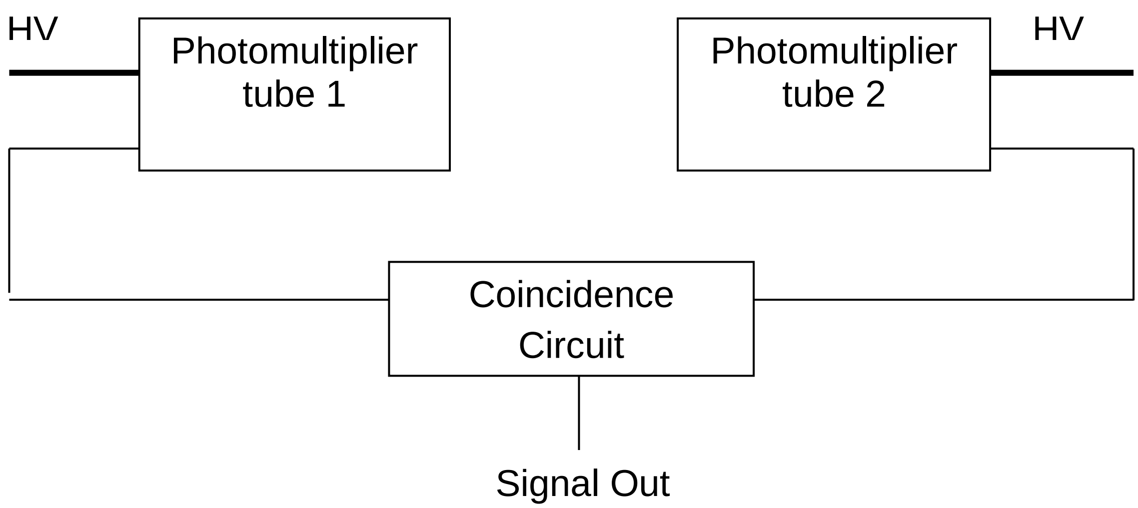
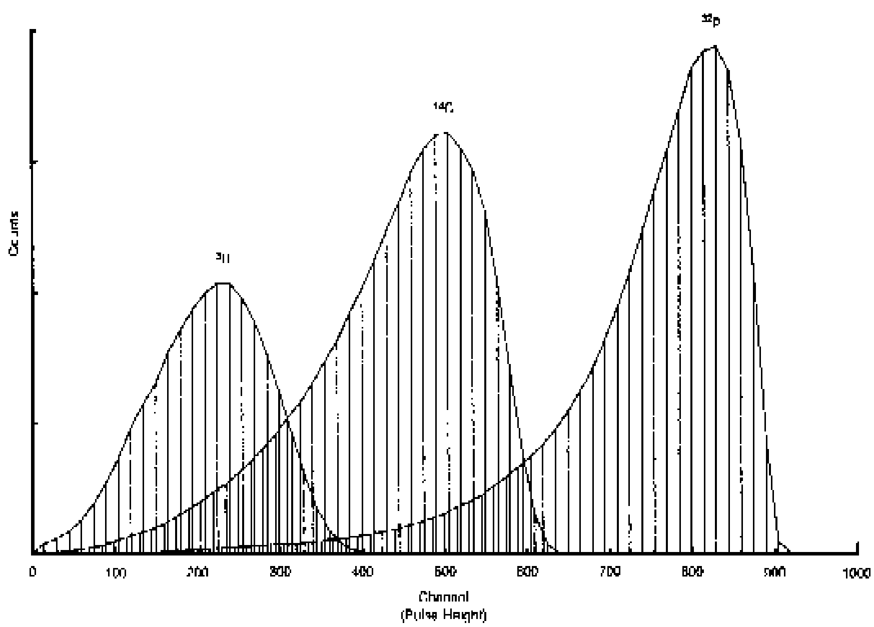


Figure 2: Pulse Height Spectra of Three Radioisotopes from a Liquid Scintillation Counter



Appendix Q

Liquid scintillation counting

Quench

Anything added to a counting vial (colour, solvents, filters, swabs) can reduce the efficiency of the scintillation process. This reduction in counting efficiency is called ing or quench, for short. The three major forms of quench are:

1. Chemical quench: Some chemicals will affect the transfer of energy between the solvent and the fluorophores resulting in reduction in the amount of light and a subsequent reduced counting efficiency.
2. Colour quench: Solid and liquid scintillators emit light in the blue region of the spectrum. Red, green and yellow colors in the counting vial absorb the light, resulting in reduced efficiency.
3. Self-Absorption: This occurs when radiation emitted by an isotope remains undetected due to absorption of the radiation by the sample itself (e.g.in precipitated cells).

Quench Correction

All samples are quenched to some degree. The counts per minute observed (cpm) may differ substantially from the true radioactive decay rate, (disintegrations per minute, (dpm), depending on the efficiency of the counting process. The counting efficiency is by definition:

Counting efficiency = cpm/dpm

dpm = cpm/counting efficiency

To determine the counting efficiency, the amount of quenching has to be known. Several methods are used to characterize and quantify the quenching for a particular sample. A common method uses the so-called "H-number" *proprietary technique by Beckman Instruments) which is assigned by an on-line analysis of the Compton electron spectrum generated in the sample by shining briefly an external standard source on this sample.

A quench calibration curve can be constructed by plotting the counting efficiency versus the H-number using a set of samples of known constant activity but containing varying amounts of quenching agent. In modern instruments, the quench curve can be stored in the machine's electronic memory such that the quenching correction is made automatically to pride directly the output as dpm.

Appendix Q

Liquid scintillation counting

Chemoluminescence

In some cases the sample may contain substances which can be excited by absorption of ambient light or other interactions. These excited states can have lifetimes in the 10's of minutes and can relax by emitting light (chemoluminescence). Such occurrences, although unrelated to radioactive events, will translate into false high activity readings for the sample. Events due to chemoluminescence can be easily discriminated as they show up at very low energy. This phenomenon may occur when counting swipe test samples of dirty areas like floors, swipe test samples of some paints or inks, and samples that have a high or low pH. Recounting, dark adapting, or changing counting parameters is sometimes necessary to clarify the difference between true radioactivity and chemoluminescence.

Static Electricity

On occasion, spurious, non-reproducible counts will be observed. The cause may be static electricity. Handling of plastic scintillation vials with surgical gloves can build up a charge on vial. It is advisable not to wear gloves when loading the LS counter.

Appendix R

Thyroid screening for radioiodine

Individuals exposed to radioiodine under the criteria of Table XIV-2 must complete a thyroid screening using the following protocol:

Thyroid Screening

Quality Control Verification

- On the day of the screening, measure and record the ambient background count rate, accumulating at least 400 counts.
- Measure and record the net count rate of a standard
- Verify that the ambient background and net standard count rates are within acceptable values

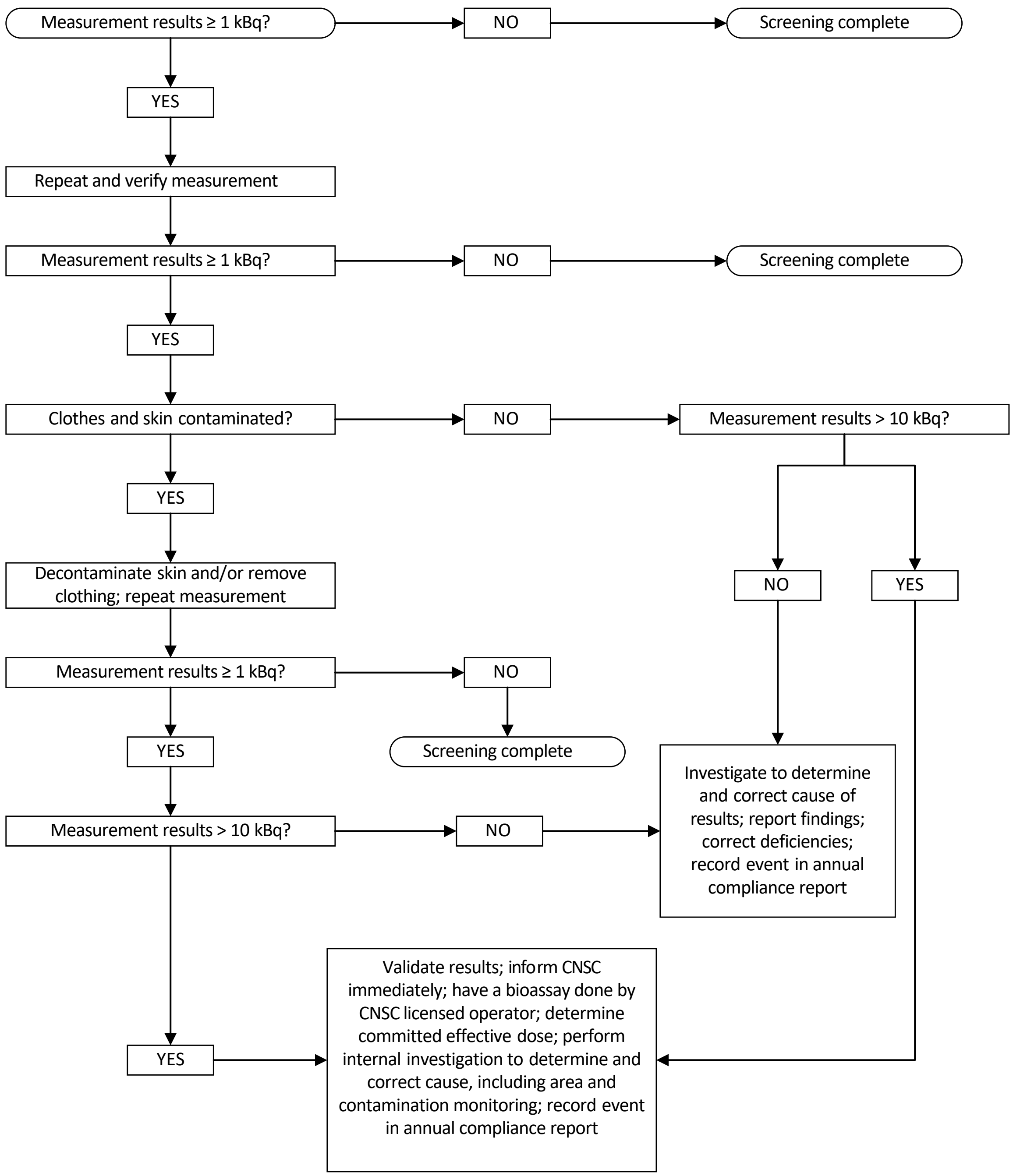
Screening Measurement

- Measure and record the exposed individual's background count rate by taking the measurement on the individual's lower thigh or with a neck phantom
- Measure and record the individual's gross count rate from the thyroid. The detector should be positioned 7 cm from the neck using the guide and positioned in the triangle formed between the Adam's apple and clavicle.
- Calculate the individual's net count rate from the thyroid (gross thyroid measurement minus background thigh measurement)
- Record the net count rate in the thyroid screening log
- Compare net counts to those in the following chart to determine appropriate action

Appendix R

Validation of Screening After Bioassays

After you have completed your bioassay, you may use this flow chart to determine what actions (if any) need to be taken depending on the measurement results obtained



Appendix S

Conversion units

Table 1: Conversion factors between radiation units

Unit Measured	To Convert From	To	Multiply By
Activity of Source	Curies (Ci)	Becquerels (Bq)	3.7×10^{10}
	Becquerels (Bq)	Curie (Ci)	2.7×10^{-11}
Energy of Source	Joules (J)	Electron Volts (eV)	6.25×10^{18}
	Electron vole (eV)	Joules (J)	1.6×10^{-19}
Absorbed Dose	Rad	Gray (Gy)	0.01
	Gray (Gy)	Rad	100
Dose Equivalent[2]	Rem	Sievert (Sv)	0.01
	Sievert (Sv)	Rem	100

1. See Table 2 for Quality Factor values.
2. Dose equivalent = Absorbed dose x Quality Factor

Table 2: Quality Factors for Ionizing Radiation

Radiation	Q-Factor
X-rays	1
Gamma Rays	1
Betas	1
Alphas	20
Neutrons	10

Appendix S

Conversion units

Table 3: Prefixes for Units

Abbreviation	Name	Factor
f	Femto	1×10^{-15}
p	Pico	1×10^{-12}
n	Nano	1×10^{-9}
μ	Micro	1×10^{-6}
m	Milli	1×10^{-3}
k	Kilo	1×10^{3}
M	Mega	1×10^{6}
G	Giga	1×10^{9}
T	Tera	1×10^{12}

^{14}C Lab info sheet

^{14}C

Low-energy Beta emitter

- **CNSC Classification:** Class C
- **Half-life:** 5730 years
- **Maximum Energy:** 156.5KeV (at 100%)
- **ALI:** 2mCi (ingestion/inhalation)
- **CNSC EQ:** 10kBq/g or 10MBq

Safety

- **Detection:** Swipe Tests
- **Instrument:** Liquid Scintillation Counter (LSC)
- **Shielding:** None required
- **PPE:** Double Gloves, lab coat, safety glasses
- **External Dose:** Not an external radiation hazard
- **Dosimetry:** None required

Special Precautions

- Use the **ALARA** principle to minimize external exposure: **A**s Low **A**s **R**easonably **A**chievable, by decreasing **time** spent around the source, increasing your **distance** from the source and using proper and adequate **shielding** (when applicable)
- ^{14}C cannot be detected with a survey meter. Contamination checks must be conducted through swipe testing and the LSC
- When working with high levels of ^{14}C (detectable with a survey meter), Plexiglas shielding may be required. Contact EHS Radiation Safety for more information
- Weekly swipe tests are required
- Contain all ^{14}C spills immediately, and contact EHS Radiation Safety in the event of any ^{14}C incident
- Some organic compounds can be absorbed through gloves; therefore, it is recommended to wear two pairs of gloves and change the outer layer as needed to avoid any skin contamination (CNSC Radionuclide Information Booklet, 2017)

EMERGENCY SPILLS or SKIN CONTAMINATION	**Security Emergency Line:** 778-782-4500 **Radiation Safety Officer:** 604-512-7238 **Radiation Safety Technician:** 604-551-5692

CNSC Radionuclide Information Booklet:
http://nuclearsafety.gc.ca/pubs_catalogue/uploads/radionuclide-information-booklet-2018-eng.pdf

Appendix T

^{32}P Lab info sheet

^{32}P

High-energy Beta emitter

- **CNSC classification:** Class C
- **Half-life:** 14.3 days
- **Maximum Energy:** 1710KeV (at 100%)
- **ALI:** 0.9mCi (inhalation) and 0.6mCi (ingestion)
- **CNSC EQ:** 1kBq/g or 100kBq

Safety

- **Detection:** Swipe Tests and Survey Meters
- **Instruments:** Liquid Scintillation Counter (LSC) and Geiger-Muller Counter (GMC)
- **Shielding:** Plexiglas or Lucite
- **PPE:** Gloves, lab coat, safety glasses
- **External Dose:** External radiation hazard
- **Dosimetry:** Extremity (finger) badge (if working with >50MBq of ^{32}P)

Special Precautions

- Use the **ALARA** principle to minimize external exposure: **A**s Low **A**s **R**easonably **A**chievable, by decreasing **time** spent around the source, increasing your **distance** from the source and using proper and adequate **shielding**
- Required Dosimeters:
  - o ≥50MBq of ^{32}P: Extremity (finger) badge
- Weekly swipe tests are required
- Contain all ^{32}P spills immediately (wearing double gloves, and all other appropriate PPE), and contact EHS Radiation Safety in the event of any ^{32}P incident
- Monitor and change gloves frequently to prevent spread of contamination
- Use a survey meter to monitor hands and feet, prior to exiting the lab space

EMERGENCY SPILLS or SKIN CONTAMINATION	**Security Emergency Line:** 778-782-4500 **Radiation Safety Officer:** 604-512-7238 **Radiation Safety Technician:** 604-551-5692

CNSC Radionuclide Information Booklet:
http://nuclearsafety.gc.ca/pubs_catalogue/uploads/radionuclide-information-booklet-2018-eng.pdf

Appendix T

^{3}H Lab info sheet

^{3}H Tritium	Safety
Very low-energy Beta emitter • **CNSC Classification:** Class C • **Half-life:** 12.3 years • **Maximum Energy:** 19KeV (at 100%) • **ALI:** 80mCi (ingestion/inhalation) • **CNSC EQ:** 1MBq/g or 1GBq	• **Detection:** Swipe Tests • **Instrument:** Liquid Scintillation Counter (LSC) • **Shielding:** None required • **PPE:** Double gloves, lab coat, safety glasses • **Internal Dose:** Urinalysis (urine bioassay) • **External Dose:** Not an external radiation hazard • **Dosimetry:** None required

Special Precautions

- Use the **ALARA** principle to minimize external exposure: **A**s Low **A**s **R**easonably **A**chievable, by decreasing **time** spent around the source, increasing your **distance** from the source and using proper and adequate **shielding** (when applicable)
- ^{3}H cannot be detected with a survey meter. Contamination checks must be conducted through swipe testing and the LSC
- Weekly swipe tests are required
- Contain all ^{3}H spills immediately, and contact EHS Radiation Safety in the event of any ^{3}H incident
- ^{3}H is volatile and can migrate (over time) through containers and gloves
  - Migration: This may result in contamination of the inside of a fridge/freezer and skin contamination. Therefore, it is advised to use double containment for storage and wear two pairs of gloves – changing the gloves every 20 minutes (CNSC Radionuclide Information Booklet, 2017)
  - Volatility: When handling large quantities of ^{3}H (mCi range), work in a fume hood to prevent external contamination and an internal dose
- Urine bioassays may be required for some users that are handling large quantities of ^{3}H (~ mCi) in intermediate level labsss

EMERGENCY SPILLS or SKIN CONTAMINATION	**Security Emergency Line:** 778-782-4500 **Radiation Safety Officer:** 604-512-7238 **Radiation Safety Technician:** 604-551-5692

CNSC Radionuclide Information Booklet:
http://nuclearsafety.gc.ca/pubs_catalogue/uploads/radionuclide-information-booklet-2018-eng.pdf

SFU SAFETY & RISK SERVICES | ENVIRONMENTAL HEALTH & SAFETY

Appendix U

Radioactive lab set-up checklist

Before you can begin working with radioactive materials, the PI and lab personnel must ensure that all items described on this checklist are completed.

If a PI intends to begin work with radioactive materials, the Radiation Safety Officer (Tel: 2-3633) or the Radiation Safety Technician (Tel: 2-3506) needs to be contacted to schedule a radioactive lab set-up inspection (email: rad-safety@sfu.ca).

Note: Canada has joined the nuclear non-proliferation treaty, and therefore all naturally occuring radioactive materials (NORMs) must adhere to the radioactive material guidlines.

Principle Investigator (PI)	
Desired Isotope	☐ P-32 ☐ H-3 ☐ C-14 ☐ Other:
Department	
Room Number(s)	

Appendix U

Radioactive lab set-up checklist

Compliance Item	Completed		
	Yes	No	Comments
Find lab space which provides the least amount of disturbance for containment of radioactivity			
Prepare work area/fume hood space, which will be designated for radioactive work only			
All bench tops and work surfaces must be covered with bench paper and radioactive tape alongside the edge of the bench			
Add second layer of disposable under pads to benchtop and work surfaces			
Add secondary containment (i.e., trays with under pads) for manipulation of source vials			
Add shielding, if applicable			
Refer to SFU's Radiation Safety website or Manual for Waste Disposal Plan and ensure all required waste 'bins' are set-up			
Radioactive spill kill kit (**see SFU Radiation Safety website for radioisotope spill response procedures form)			
Contact facilities services: • **Set up lockable storage cabinet** • **Set-up padlocks on refrigerators and freezers, which will store radioactive materials (****The Hot Lab will provide you with a lock) • **If using a bar fridge/freezer, have it bolted to the floor**			
Contact Radiation Safety staff for the following additional signage: • **Isotope info sheet** • **CNSC classification poster and spill poster** • **"Caution—Radioactive Materials"** • **"in use"** • **Radioactive door sign**			
Post internal permit at the entrance to the lab			
Check off 'radioactive' box for the hazardous material door sign, and post at every entrance to the lab			
Have a Radiation Safety Manual readily available			
Binders for swipe records, inventory sheet, and other compliance documentation **Note:** As per CNSC guidelines, **all documentation that pertains to radioactive work must be kept indefinitely**			

This form must be provided at the time of initial inspection by Radiation Safety staff.

Permit holder signature: ______________________________________ Date: ______________________

Radiation Safety signature______________________________________ Date: ______________________

Appendix V

Safe use of lead shielding

Purpose

Lead is a hazardous material and must be handled in an appropriate manner to prevent exposure to it. The purpose of this Safe Work Procedure is to protect the health of individuals working with and around lead sheets and bricks for radiation shielding within a laboratory setting.

This procedure is for activities that involve handling and cleaning lead sheets and bricks. WorkSafe BC classifies the work as Low Risk.

*Note: Eating, drinking, smoking, applying cosmetics or storing food is prohibited in any lead work area. Ensure that lead decontamination has occurred prior to conducting these activities.

Personal Protective Equipment

- Gloves – nitrile or neoprene.
- Task specific required PPE such as lab safety glasses, lab coat, etc.

Material, Equipment and Tools

- Wash area/facility with warm water, if applicable.
- Disposable towels.
- Soap.

Procedures – Lead Sheets

- Don gloves and site-specific PPE.
- Wipe down lead sheets with disposable damp towels to remove any dust.
- Place lead sheets in the desired location.
- Bend and mold lead sheets as desired.
- Conduct laboratory method.
- Remove and place lead sheets in a designated area where it will not be touched or disturbed when not in use. Ensure this area is clean and dust free.
- When handling unsealed radioactive material, cover the lead sheets with plastic bags.
- Wipe down surfaces and/or tools that were in contact with the lead sheets with a damp disposable towel.

Procedures – Lead Bricks

- Don gloves and site-specific PPE.
- Wipe down lead bricks with disposable towels to remove any dust.
- Place lead bricks in the desired location (construct a lead den).
- When not in use, store lead bricks in a designated area where it will not be touched or disturbed. Ensure this area is clean and dust free.
- Wipe down surfaces and/or tools with damp disposable towel if they were in contact with any lead.

Appendix V

Safe use of lead shielding

Clean-up

- Collect any disposable towels and gloves used during this procedure and dispose of them.
- The waste generated from handling and cleaning lead sheets and bricks does not meet the criteria for hazardous waste and can be disposed of as regular waste.
- Decontaminate: Wash hands with soap and water prior to eating, drinking, smoking, applying cosmetics, storing food, or at the end of the work activity.

General Comments

- Do not use lead bricks as doorstops.
- Use encapsulated lead sheets and bricks whenever possible.
- Do not dispose of the lead sheets or bricks as regular waste. Contact Radiation Safety Staff at rad-safety@sfu.ca to return lead shielding to Hot Lab.
- Move lead sheets and bricks using proper body mechanics, and set the lead down carefully to minimize the amount of dust generated.
- Use mobile carts and pair up with a partner to lift large and heavy lead sheets and bricks.
- Ensure that the surface holding the lead sheets and/or bricks can bare the weight.
- Do not handle lead if you are pregnant or are trying to conceive.

SFU Contacts

For further questions or concerns, please contact one of the following:

Radiation Safety Staff
radsafe-info@sfu.ca

Nick Bryans
Program Manager, Hazardous Building Materials
778.782.6558
nbryans@sfu.ca

Appendix W

Radiation Measurements and Units

Quantity	Definition	SI units	Non-SI units	Conversion
Activity (A)	The rate of radioactive decay of a substance measured in number of disintegrations per second (dps)	Becquerel (Bq) Bq/cm^2	Curie (Ci) counts per minute (cpm) cpm/cm^2	1 Bq = 1 dps 1 MBq = 0.027 mCi 1 Bq = 60 cpm 1 Ci = 3.7×10^{10} Bq 1 mCi = 37 MBq
Specific Activity (SA)	The radioactive concentration i.e. activity per unit mass or volume	Bq/kg Bq/L	Ci/kg Ci/L	-
Exposure (X)	The ability of photons to ionize air	Roentgen (R) C/kg air	-	1 R = 2.58×10^{-4} C/kg air 1 C/kg = 3880 R
Absorbed Dose (D)	The energy deposited per unit mass via ionizing radiation	Gray (Gy)	Rad	1 Gy = 100 rad 1 Gy = 1 J/kg
Dose Equivalent (H)	The absorbed dose times a qualifying factor, Q, which takes into account the effects of different kinds of radiation on a biological system	Sievert (Sv) µSv/hr	rem mrem/hr	1 Sv = 100 rem 1 Sv = Gy x Q 1 rem = rad x Q
Effective Dose Equivalent (H_E)	Dose equivalent weighed by risk to that particular body part, given by the weight factor, wt	Sv x wt	Rem x wt	Sv x wt Gonads = 0.25 Bone surface = 0.3 Breasts = 0.25 Marrow = 0.12 Lungs = 0.03 Thyroid = 0.03 Other =0.06
Committed Dose Equivalent (H_{50})	Dose equivalent applying to internally deposited radiation cumulative for 50 years	Sv	Rem	-

Appendix X

ARC SOPs

F7: ENTRY AND EXIT PROCEDURES TASC2-ARC

Revised September 2019

PURPOSE: To describe appropriate entry and exit procedures in the Animal Resource Center (ARC) in the TASC-2 building.

POLICY: To protect and maintain the health status of animals housed at the ARC and to provide personnel working with animals a safe working environment where exposure to animal pathogens and allergens is minimized.

RESPONSIBILITY: All personnel entering the barrier facility

A. INTRODUCTION:

The ARC facility houses animals of various health statuses ranging from biohazardous (BSL2, "dirty") to conventional (i.e. normal health status, not pathogen free) to SPF (specific pathogen free) to VAF (viral antibody free) or "clean" status, either with a normal or immunocompromised immune system.

Pathogens may be introduced into the facility by animals coming primarily from noncommercial sources, or by personnel bringing pathogens on their clothing or personal items from home (eg. by pet or wild rodents in the home) or from other facilities that they have visited. In turn, infectious agents or allergens (eg. from rodent proteins in urine and dander) may be carried home.

The ARC will operate as a modified barrier facility where animals are maintained in the health status in which they arrive and where protective measures (barriers) are in place to protect the status of all animals, especially those with the cleanest health status (SPF) and/or most susceptible immune status (E.g. immunocompromised). These barriers will also protect individuals, their families and the community from exposure to pathogens and allergens.

Barriers exist in the ARC through the facility design (eg anterooms, dedicated spaces), the equipment used (individually ventilated cages and biosafety cabinets), and in operational procedures, such as proper entry/exit procedures. Having a clothing policy and (PPE) Personal Protective Equipment acts as an additional protective barrier.

Compliance with this policy is mandatory. If personnel are found in non-compliance, there will be a "three strikes" rule in place: first a verbal reprimand, second a written reprimand to the researcher and PI, third will be removal of access privileges to the facility.

<u>Guidelines for all personnel entering the facility:</u>

All personnel entering TASC2 ARC must wear dedicated facility scrubs as described in the following SOPs:

a) General entry to the ARC
b) Entry and exit from animal rooms with facility designated shoes
c) PPE Personal Protective Equipment

Individual with pet rodents at home or who have visited another research facility housing animals in the last 48 hours may be required to have a full shower (including washing of hair) at the facility.
Please contact management for instructions.

Appendix X

ARC SOPs

Guidelines for service personnel and trades not entering animal holding rooms:
All service personnel and trades MUST be escorted by ARC personnel at all time and must wear a Tyvek Suite over street clothes and shoe covers over street shoes.

B. FACILITY ZONES:

The ARC is divided into zones, with each zone requiring different levels of personal protective equipment (PPE) or attire that must be worn in this zone:

1. **Hallway, Surgical suites (not in use for surgery) and Clean cage wash**
   Scrubs and facility dedicated shoes (or shoe cover)
2. **All animal holding suites including Clean & Dirty quarantine**
   Full PPE: Scrubs, facility dedicated shoes, gowns, shoe cover, hair bonnet, mask and gloves
3. **Surgical suites (surgery in progress)**
   Scrubs and facility dedicated shoes (or shoe cover). Gown/ bouffant and mask in prep area with surgical greens in surgery room.
4. **Dirty cage wash:**
   Full PPE: Scrubs, facility dedicated shoes, gowns, shoe cover, hair bonnet, mask and gloves
5. **Necropsy**
   Full PPE: Scrubs, facility dedicated shoes, gowns, shoe cover, hair bonnet, mask and gloves
6. **Clean receiving/Laundry room**
   Scrubs and facility dedicated shoes (or shoe cover)
   NOTE: When the loading dock doors must be open to receive supplies, a gown to protect your scrubs and shoe covers to protect your dedicated shoes must be worn. The floor of the receiving area must be washed before shoe covers are removed.
7. **Dirty receiving**
   ** This area is normally accessed from the back of the building in "street" clothes.
   If being accessed from the barrier, users are required to wear a Tyvek suit over scrubs, bouffant cap, mask, gloves and additional shoe covers.
   See SOP Entry into the ARC Service and Isolation/Quarantine areas
8. **Level 2 rooms**
   Full PPE: Tyvek suit, scrubs, facility dedicated shoes, disposable gowns, shoe cover, hair bonnet, mask and double gloves

C. PERSONNEL ENTRY PROCEDURES VIA LOCKER ROOMS

Entry into and exit from the facility must occur through the female and male locker rooms.
All entering the facility must sign in and out in the logbook by the Admin office.
A secured approved fob key is required to access the TASC2 facility.

1. The locker rooms are divided into a "dirty" and "clean" side:
   a) **The dirty side** is located at the entrance to the facility and elevators; it has a washroom and shower. Street clothing is permitted in this space.
   b) **The clean side** is located through the door separating clean from the dirty past the washroom and shower
2. All personnel must remove their street clothes and place them in available lockers or on hooks provided. See SOP General Entry to the Animal resource center
   a) Put on sterile scrubs which are located on the rack.
   b) If you have facility dedicated shoes, remove street shoes and proceed through to the clean side.
   c) If you DO NOT have facility dedicated shoes, keep your street shoes and proceed through to the clean side.

d) Walk through the door past the washroom into the clean side. You MUST NOT step and/or cross over the yellow line on the floor.
e) Put on dedicated facility footwear or put on shoe covers over street shoes.
IMPORTANT: When putting dedicated facility shoes on or shoe covers over street shoes swing your foot on the clean side (over yellow line) before putting the foot down on the floor so it is now located on the "clean" side.
f) Sanitize your hands at wall sanitizer dispenser located by the door into the main facility.

D. PERSONNEL EXIT PROCEDURES

1. When leaving the facility, enter the clean side of the change room
2. When removing facility dedicated shoes and/or shoe covers
   IMPORTANT: Sit on the bench and swing your foot towards the dirty side (over yellow line) before putting the foot down on the floor so it is now located on the "dirty" side.
3. Place facility dedicated shoes on the shelving unit, shoe covers are disposed of in the trashcan.
4. Enter the dirty side of the locker room.
5. Remove scrubs and put on street clothes
6. Place scrubs into laundry basket situated on the clean side of the locker room.
7. Wash your hands or use sanitizer prior to leaving the change room

E. TRANSPORT OF ITEMS IN AND OUT OF THE BARRIER FACILITY

1. Items to be left inside the barrier such as new equipment, dedicated barrier shoes or computer equipment must go through the Vaporized Hydrogen Peroxide decontamination. This is arranged through the Manager and Senior Technician.
   See Bioquell Clarus C SOP
2. Items that will be used within the facility and taken with users when they leave must be decontaminated with a surface disinfectant prior to entry. Only items that are absolutely necessary for the task to be completed and are not readily available inside the barrier can be transported in. Unnecessary items such as personal electronics, back packs, extra pens or paper, etc. should not be transported in. If an item such as a cellphone or iPad needs to enter the facility, it can be placed inside a sealable plastic bag and the outside of the bag can be disinfected. Item use and function must be done through the plastic bag.
   a. The door to the pass-through chamber (room 6472.1) is opened using a facility key fob from the main entrance area.
   b. Within the room are two small stainless steel carts. Without stepping into the room, reach in to roll one of the carts close enough to place the item on.
   c. Using the spray or the ready-to-use pre-moistened disinfectant wipes, thoroughly cover the item with a light layer of disinfectant. The item should be wet enough to stay damp for the 5 minute disinfectant contact time.
   d. Leave the item on the cart and close the door. Proceed into the locker room and enter the facility.
   e. Once you are in the facility, open the door to the room from the hallway, reach in and roll the cart close enough to retrieve the item. Any excess disinfectant can be removed using the paper towel provided.
   f. Ensure that the door to this room is closed when you are finished.
   g. Removal of items from the facility will go through the same process. Items leaving the facility are disinfected to protect public and lab spaces from any possible contaminant or allergen.

Appendix X

ARC SOPs

F16: HAZARDOUS WASTE DISPOSAL

Revised July 2019

PURPOSE: To outline the procedure to be followed for the disposal of hazardous waste at SFU.

POLICY: To ensure safe and proper disposal of hazardous waste as per SFU EHRS procedures.

RESPONSIBILITY: ACS Technicians

Hazardous waste is picked up at Burnaby campus on Tuesday and Friday 10 am to noon.

Pickup Procedure

1. To request pickup, use the online request system at: https://hazmatwaste.its.sfu.ca
2. Requests can be made for single pickup or recurring (weekly) pickup.
3. For next day pickup, submit your request before 3 pm on Monday and Thursday.
4. Autoclave bags, sharps container, labels and solvent waste containers are available at Science Stores.
5. Login to the online request system using your SFU login and password.
6. Using the menu on the left side of the page, select "Request waste pickup"
7. Fill in the Request information and press the blue buttons "Next" and "Add Detail"
8. Fill in all information for each individual item. Pressing "Add Detail" allows you to enter information for multiple items.
9. When complete with all individual entries, press "Save & Exit". Your request will be generated and you will receive an email verification.

PROCEDURE:

Chemical Waste:

1. Wear gloves to handle chemicals to be disposed of.
2. Identify each chemical along with the following:
   a) Name (chemical name possible but no formulas)
   b) Quantity (i.e.. how many bottles)
   c) % strength (concentration)
   d) Chemical state (gas, liquid, solid)
   e) Size of the container (e.g. 500ml, 1L)
   f) Amount of chemical left in container
3. Segregate different chemicals into separate, labelled, 5L white/translucent containers and fill to "max fill line" (75%).
4. Collect and store waste chemicals according to compatibility and place in secondary containments bins when practical.

Level 1 Biohazardous Solid Waste (Animal and Fish Carcasses)

1. Place all tissue and bodies in clear, colorless 6lb or 8lb plastic waste bags. These bags can be stored in the necropsy room fridge at ARC prior to being put into the cadaver freezer in room 6200. At the Alcan aquatic facility, the carcasses are taken to the freezer located in room B8200 in the Shrum building Biology department and the Animal Care Facility the tissues and bodies will go directly into the designated carcass freezers in room 126.
2. All frozen tissue must be put into the supplied red plastic waste containers prior to pick up. Total weigh of each container <u>must not exceed 10 kg</u>.
3. A pick up request is placed through the online request system.

Appendix X

ARC SOPs

Level 2 Biohazardous Solid Waste

1. All waste must go into orange autoclave bags, be loosely closed with autoclave indicator tape and be autoclaved on site.
2. After autoclaving, the bags can be put into the appropriate waste stream and a pick up request is placed through the online system.

Sharps

1. All sharps including needles, syringes, scalpel blades, razor blades and other sharp metal items are to be put into red Sharps, Biohazard containers.
2. When containers are full, the lids are sealed and a piece of autoclave indicator tape placed on the container.
3. Sharps containers are autoclaved on site and a request for waste pick up is put in for disposal.

Radioactive Waste

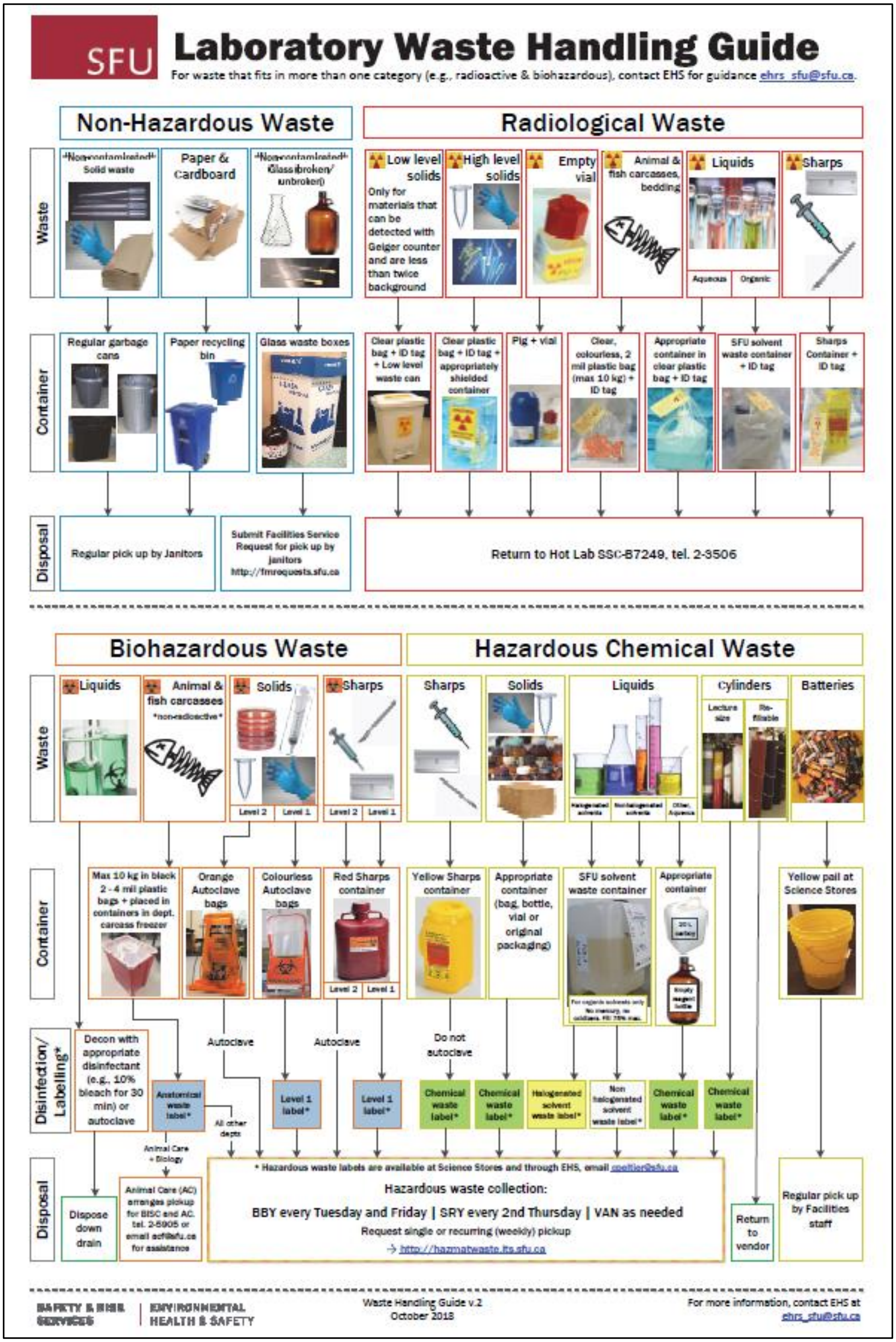
All radioactive waste from the "hot" room 6420 is swipe tested to ensure no external contamination before being sent to the SFU Hot Lab for proper disposal. Radioactive waste tags are attached to all items leaving the room and the lab members are responsible for transport.

REFERENCE

See below for laboratory waste handling guide

Appendix X

ARC SOPs



Appendix X

ARC SOPs

H19-DAILY ROUNDS-HEALTH CHECK IN ISOTOPE ROOM 6420

Revised January 2019

PURPOSE: To describe the daily animal room health check in an orderly manner to avoid radioactive isotope contamination.
POLICY: The daily room health check is to ensure that all animals are healthy, have an adequate supply of food and water, dry bedding and a comfortable environment at all times.
RESPONSIBILITY: Animal Health Technicians listed on a current SFU Radioisotope Permit

---

NOTES:

a) Animal Health Technicians and Lab Members must have completed SFU Radiation Safety Training.
b) Only Animal Health Technicians and Lab Members that are listed on current SFU Radioisotope Permits that are posted in the anteroom are allowed into this animal holding suite.

IMPORTANT NOTE:

- Rodent cages with isotope treated animals MUST NEVER be opened in any area outside of the Biological Safety Cabinet within room 6420.2
- These rodents MUST NEVER be handled without appropriate PPE.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

1. For animal daily health check: Upon first entry to the anteroom, put on shoe covers, bouffant cap, mask, gloves and a Tyvek suit. If you are returning to the animal holding room, you can leave the Tyvek suit on the hooks inside the anteroom and re-use the suit.
2. Areas within the isotope used area that have bench coat on the floor require additional PPE to be worn before stepping onto these areas as they are considered a "hot zone". These areas are the space directly in front of the animal holding rack and the procedural space.
3. To enter a "hot zone", put on a second pair of shoe covers, a second pair of gloves and a disposable gown.
4. The disposable gowns can be left hanging on the hooks in the procedure room when you have completed your work in that area.
5. When leaving the animal holding area, used PPE is placed in the Low Level Waste next to the door to the anteroom. No PPE worn within the animal holding area during an active study should be worn into the anteroom.

HANDLING ISOTOPE TREATED RODENTS OR CONTAMINATED EQUIPMENT

1. Always work with an additional person. One person will be designated as the "hot" person, this way, only one person is in contact with the potential isotope activity and the second person assists by handling all non-radioactive items.
2. Anything in direct contact with isotope treated animals should be considered "hot" (having radioactive contamination). Until the items have been swipe tested and the results are within acceptable limits of activity, all precautions must be taken not to transmit any radioactivity to any other surfaces through contact.
3. When working alone in the isotope housing room, there should be no handling of cages, bottles or animals unless necessary for the immediate health or welfare of the animals.
4. Cages with treated animals must never be opened outside of the running Biological Safety Cabinet.
5. Disposable pads provided in the procedure area can be used as a temporary surface to place any "hot" items on and will be disposed of as High Level Contaminated Waste.
6. Double gloves should always be worn and the outer layer must be changed between contact with "hot" items and clean areas.

REFERENCE

(PPE) Personnel Protective Equipment including optional respiratory PAPR suit

EMERGENCY PROCEDURES

IN AN EMERGENCY CALL 911

CAMPUS SECURITY

**EMERGENCY/
FIRST AID LINE**
778.782.4500

**NON-EMERGENCY/
SAFEWALK LINE**
778.782-7991

EMERGENCY NOTIFICATIONS
WWW.SFU.CA/SFUALERTS

- In an emergency, visit www.sfu.ca and follow @SFU on Twitter.
- Download the SFU snap app

SEE SOMETHING, SAY SOMETHING

- Report suspicious persons/ objects to Campus Security.

REPORT SAFETY HAZARDS AND INCIDENTS
WWW.SFU.CA/EMERGENCY

SFU SAFETY AND RISK SERVICES

FIRE

- Pull the nearest fire alarm, leave the area and close the door
- Evacuate the building via the nearest exit, do not use elevators
- Proceed to the assembly area
- Do not re-enter until authorized by Fire Department or Campus Security

EARTHQUAKE

- **Drop, cover, hold on** under a heavy desk or table, interior wall, or corner
- Wait 60 seconds after the shaking stops
- Proceed to the designated assembly area

ACTIVE THREAT

- **Run** - Evacuate the area if it is safe to do so
- **Hide** - Lockdown and hide yourself if you cannot evacuate safely
- **Take action** - As a last resort, commit yourself to delay, block or overcome the threat

CARDIAC ARREST

- **Phone 911** and shout for an AED. AED locations: www.sfu.ca/aed
- **Push** hard and fast in the centre of the chest
- **Use an AED** following the automated verbal instructions

SEVERE WEATHER

- Know before you go. Visit www.sfu.ca and follow @SFU on Twitter

SHELTER-IN-PLACE

During hazardous outdoor environments:

- Seek shelter indoors
- Close exterior doors and windows
- Stay indoors until officially advised