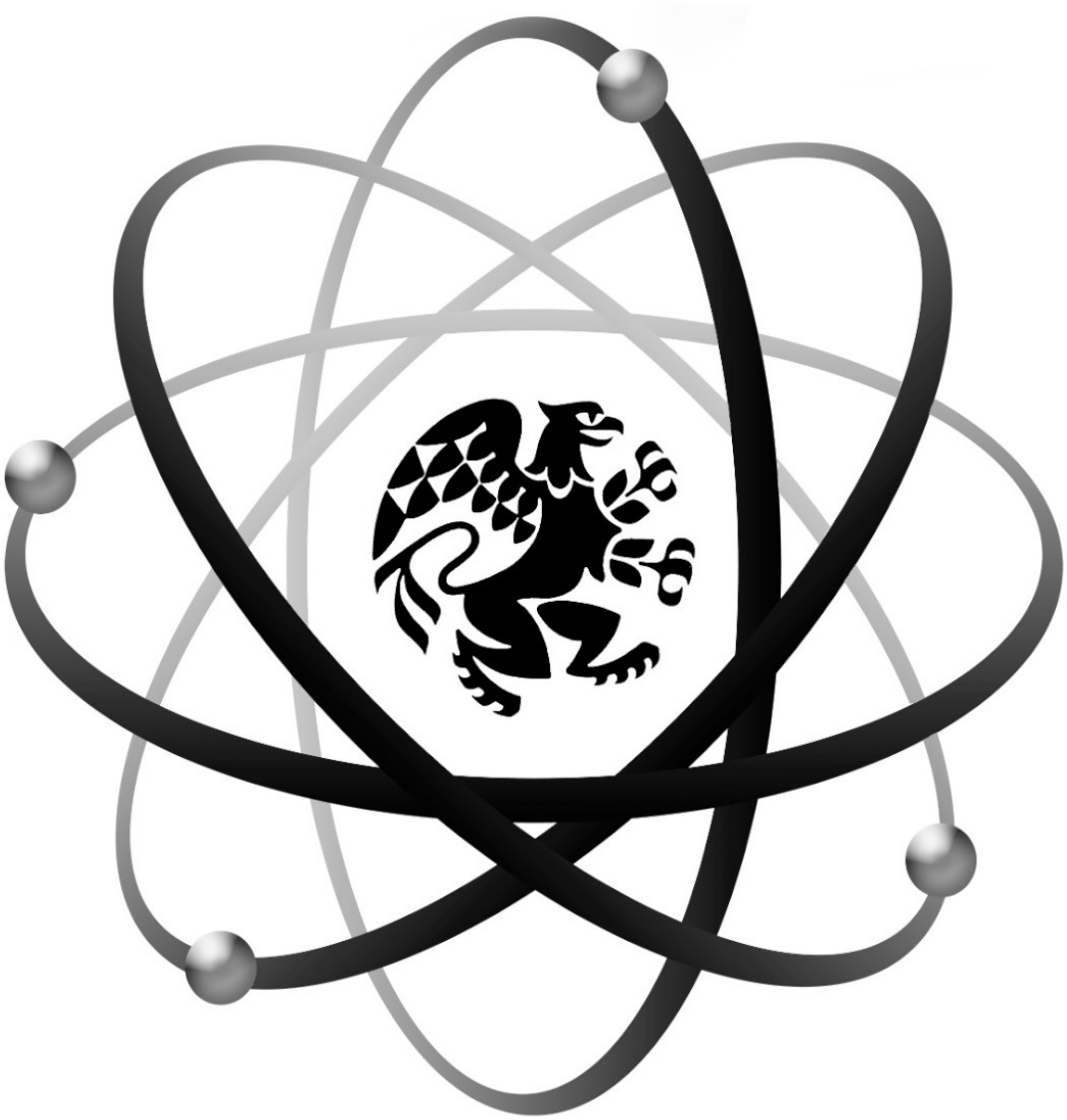
Reed College
Radioactive Materials
Policy and Procedures Manual

June 2016



Emergency Information

Fire, Ambulance/Rescue, Police.....#, 911

Community Safety.....503/788-6666

Reed Health Services (M-F 9 am - 5 pm).....503/777-7281

Radiation Safety Officer (RSO) (April Karr).....503/777-7788

Reactor Director, Asst RSO (Melinda Krahenbuhl).....503/777-7222

Reed Physical Plant Maintenance.....503/777-7283

Mailroom Manager (Jon Edgington).....503/777-7214

Reed Public Affairs …….....503/777-7289

Poison Control Center (OHSU).....#, 800/222-1222

State of Oregon Radiation Protection Services.....#, 971/673-0490 [see Appendix A]

Oregon Occupational Safety and Health Administration (OR-OSHA)……...#, 503/378-3272 [see Appendix A]

Please note the location of the following:

Nearest Fire Alarm Pull Station: _____

Nearest Fire Extinguisher: _____

Nearest Emergency Shower/Eyewash: _____

Nearest First Aid Kit: _____

Nearest Spill Kit: _____

Nearest Automated External Defibrillator: _____

Outside Assembly Point Location _____

Shelter-in-Place Location: _____

SDS Locations _____

Useful Websites:

Oregon Administrative Rules (OAR) for the Control of Radiation, Chapter 333, Divisions 100 to 120: http://arcweb.sos.state.or.us/pages/rules/index.html

Nuclear Regulatory Commission site: http://www.nrc.gov/

Reed College RAM test link: https://iris.reed.edu/ramtest.taf

Reed College ancillary user link: http://www.reed.edu/ehs/radiation_safety/ancillary_radiation_safety.html

Reed College Radioactive Materials Policy and Procedure Manual

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POLICY

1. RADIATION SAFETY COMMITTEE (RSC)

A. RESPONSIBILITIES

1. Be familiar with all pertinent Oregon rules, the terms of the license, and information submitted in support of the request for the license and its amendments.

2. Establish a program to ensure that all individuals whose duties may require them to work in the vicinity of radiation or radioactive material (e.g., security, maintenance, and custodial personnel) are properly instructed as required by the Oregon Administrative Rules (OAR) 333-111-0010, part of the Oregon rules for controlling radiation.

3. Review the training and experience of all individuals who use or handle radioactive materials (RAM) and determine that their qualifications are sufficient to enable them to perform their duties safely and in accordance with the rules and conditions of the license.

4. Review all requests for authorization to use radiation or radioactive material within the institution on the basis of safety, and approve or deny the requests based on the limitations of the rules, the license, and the "As Low As Reasonably Achievable" (ALARA) principle.

5. Prescribe special conditions that will be required during a proposed method of use of radioactive material (e.g., requirements for bioassays, physical examinations, and special monitoring procedures).

6. Review quarterly the summary report of the occupational radiation exposure records of all personnel.

7. Review annually the summary report of the entire Radiation Safety Program provided by the Radiation Safety Officer (RSO) to determine that all activities are conducted safely, in accordance with Oregon Rules and the conditions of the license, and consistent with the ALARA program and philosophy. The review must include an examination of records, reports from the RSO, results of inspections, written safety procedures, and the adequacy of the management control system.

8. Recommend remedial action to correct any deficiencies identified in the radiation safety program.

9. Maintain written minutes of all committee meetings, including members in attendance, discussions, actions, recommendations, and decisions.

10. Ensure that the radioactive material license is amended when necessary.

11. Support the RSO in enforcing the rules and procedures specified by the license and procedures.

B. ADMINISTRATIVE INFORMATION

1. The Committee shall meet as often as necessary to conduct its business, but shall meet a minimum of one time per calendar quarter.

2. Primary membership includes the following:

    - One faculty member from each department where radioactive materials are housed, preferably one who uses or stores radioactive materials
    - The RSO
    - The Assistant RSO
    - A representative from the reactor facility
    - The campus hazardous materials manager
    - A representative of the Administration who does not use or store radioactive materials nor is an RSO.

3. The Administration may appoint alternate members to participate in meetings in the case of absent primary members and may consider appointing as adjunct members representatives from security, facilities services, the student body, and other departments.

4. A simple majority of the primary membership of the RSC is necessary to approve new Principal Users of radioactive materials. Principal Users (training outlined in Policy 13.a) are typically faculty or staff who supervise a lab using radioactive materials, such as Faculty, Researchers, the Reactor Director, the Reactor Operations Manager, the Radiation Safety Officer, or the Assistant Radiation Safety Officer.

5. The RSO will approve new Authorized Users working under the guidance of a Principal User after the applicant has adequately completed the training and testing requirements described in Policy 13.c and Procedure 8: Personnel Training. Authorized Users may be students, non-Reed employees, visitors, or others who use radioactive materials under the direction of a Principal User.

6. Voting may be conducted over electronic mail. To establish a quorum for voting on issues affecting policy, procedure, or the radioactive materials license, one half of the primary membership, including the RSO and Administration representative, must vote.

2. RADIATION SAFETY OFFICER (RSO) DUTIES

A. Be familiar with all applicable laws, rules, and license application guides, and ensure that license applications are properly filled out and submitted in a timely fashion. Ensure that the institutional radiation use and safety programs comply with the license application and conditions.

B. Establish and maintain record systems of the following, unless otherwise indicated:

1. Dosimetry reports
2. Bi-weekly and/or monthly wipe tests
3. Bi-weekly and/or monthly surveys of lab areas (maintained by RSO and/or Reactor Director)
4. Source wipe tests (maintained by RSO and/or Reactor Director)
5. Semi-annual inventories (maintained by RSO and/or Reactor Director)
6. Annual audits of radiation safety program
7. Instrument calibrations (maintained by Reactor Director)
8. Radiation Safety Committee minutes and communications
9. State inspections and communications
10. Principal User authorizations
11. Receipt, Use, and Disposal Logs
12. Training records
13. Changes to the Reed College Radioactive Materials License
14. Radioactive waste off-site disposal records (maintained by Reactor Director)
15. Lab close-out records
16. Decommissioning

C. Prepare an annual report presented to the RSC that reviews and summarizes all activities pertaining to radioactive materials, including training, surveys, wipe test dates, waste disposal, ordering of materials, and other information.

D. Review personnel dosimetry reports quarterly or more often if required. Advise individual radiation workers of any unusual exposure. Determine the cause of all overexposures, as defined in Policy 3.a.viii, to preclude recurrence.

At the conclusion of each calendar quarter, perform a review of occupational exposure to users and workers to determine that the exposures are within the limits established for the ALARA program. At the conclusion of each calendar year and upon end of employment, apprise each employee of annual accrued dose.

E. Ensure that individuals working with radiation have appropriate protective devices such as shielding, ventilation, clothing, gloves, remote handling equipment, dosimeters, instrumentation, and facilities, which aid in keeping exposures ALARA.

F. Ensure that all individuals who work with, or in the vicinity of, radioactive material or sources of radiation have sufficient training and experience to enable them to perform their duties safely and in accordance with the law, rules, and the conditions of the license.

G. Ensure that individuals use radioactive material and radiation in a safe manner and in compliance with the law, rules, and the conditions of the license. This includes reviewing, as necessary, training programs, equipment, facilities, supplies, and procedures. (See Procedure 1: *Safe Use of Radioactive Materials*.)

H. Ensure that the use of radioactive material is consistent with the ALARA principle and program.

I. Identify program problems and solutions.

J. Act as liaison with regulatory authorities by doing the following:

1. Provide assistance during inspections and audits.

2. Communicate with state agencies as indicated by the following:

- Submit a written amendment request to State of Oregon Radiation Protection Services before making any change that would render the current Radioactive Materials License inaccurate.

- Notify the State of Oregon Radiation Protection Services in the event of:

  - Within 5 days of any positive leak test result of a sealed source.

  - Within 30 days in a report stating remedial action taken after an accident or incident.

- Notify the State of Oregon Radiation Protection Services and/or Oregon Occupational and Safety Administration (OR-OSHA) of any radiation accident or incident that meets the requirements summarized in Appendix A: *Emergency Notifications*.

K. Ensure a semi-annual inventory (Form 1) is performed of all sealed sources received or possessed and all radioisotopes in authorized areas, in accordance with OAR 333-102-0910. Maintain an inventory control of radioisotopes at the institution and ensure that license quantities are not exceeded. Ensure all surveys, calibrations, and leak tests are performed on time.

L. Post conspicuously the Oregon Department of Human Services form, "Notice to Employees," and other items required under OAR 333-111 as well as notices of Items of Noncompliance resulting from Radiation Safety Committee inspections.

M. Supply employers of terminated occupationally-exposed personnel with radiation exposure records as required.

N. Keep records of receipts of incoming radioisotopes and surveys of incoming and outgoing shipments. Ensure that all incoming and outgoing radioactive material shipments are properly packaged and labeled according to DOT requirements, and that proper shipping papers accompany shipments. Ensure that radioactive materials are disposed of properly and that records are maintained of all radioactive wastes disposed (See Procedure 5: *Waste Disposal*).

O. In conjunction with the Radiation Safety Committee, continually review the radiation safety program for adherence to ALARA concepts. Ensure that all workers dealing with radioactive materials follow the safety program. Investigate any deviation from the program and take any necessary action.

P. Schedule briefings and educational sessions to inform workers of the following radiation safety rules and procedures:

1. For all new personnel working with or around radioactive materials.

2. With each change in license condition or safety program which will affect the employee.

3. Provide refresher advisories for all personnel. This includes instruction in the ALARA program and philosophy.

3. PERSONNEL DOSIMETRY AND BIOASSAY PROGRAMS

A. DOSIMETRY PROGRAM

1. Any individual who is likely to exceed 10% of their exposure limit is required by OAR 333-120-0210 to receive personal dosimetry. However, the policy of Reed College is more conservative as indicated in the following paragraphs. Appendix B: *Worker Exposure Levels*, shows both regulatory and recommended exposure limits.

2. All individuals who are occupationally exposed to penetrating ionizing radiation on a regular basis will be issued appropriate dosimetry monitoring devices, which will be processed by a National Voluntary Laboratory Accreditation Program (NVLAP) certified contract service at least on a quarterly basis.

3. The RSO and/or Reactor Director will review, sign, and date all exposure reports promptly upon their receipt.

4. All individuals who potentially may be occupationally exposed to penetrating ionizing radiation on an occasional basis will be issued a personal self-reading dosimeter (e.g., an Electronic Personal Dosimeter (EPD).

5. Individuals who work exclusively with low-energy beta emitters will not be issued radiation dosimeters. Classes that perform occasional experiments with microcurie-level sources will not be issued dosimeters. Past data show that no individual exposures greater than ten percent of the allowable annual limit have occurred in these classes.

6. Whole body and ring dosimetry will be issued and exchanged quarterly.

7. The RSO or Reactor Director will maintain a record of personnel dosimetry records. Each individual who received a measurable dose will receive a report of his or her annual dose at the end of the fiscal year and at the end of employment.

8. Any reported whole body dose greater than 50 mrem per quarter or any extremity dose greater than 100 mrem per quarter will be investigated by the RSO and/or Reactor Director to determine the cause of the exposure. The RSO will prepare a written report for the RSC. In addition, the RSO or designee may investigate any dose at their discretion.

9. If a user notifies the RSO in writing that she is pregnant, the RSO will take extra measures, such as providing a second badge issued monthly, to ensure the fetus receives less than 500 mrem during the gestation period.

B. BIOASSAY PROGRAM

1. Any individual using tritium or working in an area where tritium intake is possible will inform the RSO or designee prior to the activity when any of the following conditions apply:

    - When handling organic H-3 in single packages with an activity of 10 millicuries (10 mCi, 370 MBq) or more
    - When handling inorganic H-3 in single packages of 50 millicuries (50 mCi, 1.8 GBq) or more
    - When deemed necessary by the RSO or designee

    Each individual will submit a urine specimen to the RSO or Assistant RSO before work begins in order to establish a baseline. In addition, the individual will submit a urine sample within 12-48 hours of opening the container or otherwise using the material. The sample will be analyzed with a liquid scintillation counter, using procedures developed by Oregon State University Radiation Center in their RCHPP 14.

2. Any individual handling 1 millicurie (1 mCi, 37 MBq) or more of Iodine-125 will inform the RSO prior to the activity and will undergo a thyroid scan before work begins in order to establish a baseline. In addition, the individual will undergo an additional thyroid scan within 24-48 hours of opening the container or otherwise using the material. The RSO will arrange the scan with Oregon Health and Science University (OHSU) Radiation Safety Lab.

4. SAFE USE OF RADIOACTIVE MATERIALS

Areas where radioactive materials are stored, prepared, and used will be monitored for contamination in compliance with Procedure 1: *Safe Use of Radioactive Materials.* Individuals found in violation of these rules will be subject to sanctions determined by the Radiation Safety Committee.

5. EMERGENCY PROCEDURES

The RSO and/or designee will take charge in all emergency situations in the event of major or minor spills (as defined in Procedure 2: *Emergencies*) or release of radioactive material, to ensure correct emergency decontamination and protection procedures are carried out. The RSO will also evaluate the situation that led to the emergency to reduce the chance of reoccurrence and will submit a report to the State of Oregon Radiation Protection Services if necessary (see Procedure 2: *Emergencies*).

6. LEAK TEST PROGRAM FOR SEALED SOURCES

The Reactor Director or designee shall perform leak tests of sealed sources per Procedure 3: *Sealed Source Leak Test.*

7. AREA SURVEYS

Individuals using radioactive materials must conduct bi-weekly (interval not to exceed 19 days) surveys per Procedure 4: *User Surveys.* **NOTE: When radioactive contamination levels exceed 1000 dpm/100 cm^2 above background (approximately 4.5 x 10^{-4} μCi/100 cm^2) in an area other than the reactor sample removal area north of the reactor pool, the RSO must be notified before the end of the next business day.** Areas where radioactive materials are stored must be surveyed at least once a month.

8. INVENTORY

A. REQUIREMENTS

1. Principal Users shall conduct a semiannual physical inventory of all radioactive material possessed under the license. Inventories shall be submitted to the RSO semiannually (interval not to exceed 32 weeks). Form 1: *Semi-Annual Inventory* or an equivalent form may be used.

2. Each inventory shall include the date of the inventory, the name of the Principal User completing the inventory, the quantity and nuclide of materials inventoried, the chemical form of the material, the identification number of the material (if applicable), and its physical location. Sealed sources must also be inventoried.

B. EXEMPTIONS

Radioactive material that was made radioactive in the Reactor facility may be excluded from semiannual inventories.

9. WASTE DISPOSAL

A. INTRODUCTION

Waste disposal is a very expensive and strictly regulated process. To ensure compliance with regulations and to minimize releases of radioactivity to the environment, Reed College requires that users of radioactive materials follow the procedures described in Procedure 5: *Waste Disposal.* Reed College strives to reduce the amount of radioactive waste generated.

B. RESPONSIBILITIES

1. Principal Users

- Through supervision, instruction, and careful monitoring, ensure that no radioactive materials are discarded as ordinary trash or as other non-radioactive hazardous waste.

- Minimize the disposal of non-radioactive materials as radioactive waste.

- Minimize the production of radioactive waste and the cost of disposal (e.g., by using materials with short half lives).

- Follow disposal steps established in Procedure 5: *Waste Disposal*. Properly package and label waste for transfer to the campus radioactive waste storage facility.

- Restrict sink disposal to sinks registered with the RSO. Ensure that the disposal is within authorized limits and the wastes are soluble or dispersible in water. Keep records of disposals.

- Train all new Authorized Users for whom they are responsible in proper laboratory techniques regarding radioactive materials.

2. Authorized Users

- Follow instructions for packaging and labeling radioactive waste per Procedure *5: Waste Disposal*.

- Ensure that radioactive materials are never placed into regular trash containers or wastebaskets, or disposed through any other method that is not controlled with respect to radioactivity.

- Minimize the amount of radioactive waste generated. Record the proper information for each sink disposal of radioactive material as described in Procedure 5: *Waste Disposal*. Activity must be within acceptable limits and the material must be soluble or dispersible in water and non-hazardous.

3. Radiation Safety Officer

- Keep a file of all radioactive waste disposal regulations and ensure the college follows them.

- Receive all appropriately labeled radioactive wastes generated at the college, which require disposal outside the laboratory. Package and label them for appropriate disposal.

- Keep detailed records of amounts and methods of disposal of radioactive wastes as described in Procedure 5: *Waste Disposal*.

- Monitor and record all releases from decay-in-storage per Form 5: *Decay-In-Storage Log* or the Reed Research Reactor Irradiation Request Form (RRR SOP 10A)

10. RADIOACTIVE MATERIAL PACKAGES

All radioactive material packages will be received and surveyed in accordance with the steps in Procedure 6: *Radioactive Materials Package Ordering and Receipt*.

11. AUDITING RADIOACTIVE MATERIALS

The Radiation Safety Committee in conjunction with the Radiation Safety Officer will continually review the content and implementation of the Reed College Radioactive Materials Program for efficiency and effectiveness in ensuring a safe working environment.

The overall Reed College Radioactive Materials Program will be audited annually for content completeness, including the RSO record keeping and the annual report. This audit will be conducted either by the Radiation Safety Committee or by an outside consultant.

12. PERSONNEL TRAINING PROGRAM

A. INSTRUCTION:

Instruction will take place at the following times:

- Before assuming duties with, or in the vicinity of, radioactive materials.
- During refresher training.
- Whenever there is a significant change in duties, rules, or the terms of the license.

B. PRINCIPAL USERS

Principal Users will be trained in accordance with Procedure 8: *Personnel Training* which requires new Principal Users to pass an examination and all Principal Users to fill out Form 8: *Application for Use of Radioactive Materials* before using radioactive materials.

C. AUTHORIZED USERS

Authorized Users may be students, non-Reed employees, visitors, or others who use radioactive materials under the direction of a Principal User.

Authorized Users will be trained in accordance with Procedure 8: *Personnel Training* and will be assigned to work with a Principal User.

D. ANCILLARY PERSONNEL

Those employees whose duties may bring them in the vicinity of the radioactive materials (e.g., custodians, maintenance personnel, security officers) will be trained in accordance with Procedure 8: *Personnel Training* as part of their Right-To-Know training.

E. REFRESHER TRAINING

A triennial overview of the Reed College Radioactive Materials Policy and Procedures manual will be presented to all active Principal Users. Inactive Principal Users will receive refresher training before resuming use of radioactive materials. Authorized Users and ancillary personnel will receive refresher training triennially (interval not to exceed 190 weeks). All users will receive refresher training whenever significant changes to duties, rules, or the terms of the license occur.

13. CALIBRATION OF SURVEY INSTRUMENTS

Instruments will be calibrated in accordance with Reed Research Reactor SOP 43 or other procedures approved by the Reactor Operations Committee.

14. MONITORING, CONTROL, AND SECURITY

A. MONITORING

Per Procedure 4, the RSO or designee will conduct bi-weekly surveys of areas where radioactive materials are prepared or used and at least a once a month survey for radioactive materials in storage. Bi-weekly surveys are to be completed in intervals not to exceed 19 days; monthly not to exceed 40 days. The surveyor will use Form 2: *Radiation Survey Report* to report wipe and survey findings. The location of wipes or surveys taken will be noted on the form.

A visual inspection of the work area will be completed at the time of the survey. Any violations of proper work procedures will be noted and reported to the Principal User.

B. CONTROL

Violations found during the survey will be discussed with the Principal User. Three violations by any Principal User in a calendar year may result in a temporary suspension of radioactive materials authorization. The Radiation Safety Committee shall determine the length of suspension.

Serious violations (e.g., mouth pipetting, use of unauthorized radioactive materials, unauthorized users of radioactive materials, unauthorized waste disposal, excessive contamination) may result in immediate suspension of radioactive materials authorization. The situation will be reviewed and a determination made by the Radiation Safety Committee.

C. SECURITY

Entrances to areas that contain radioactive materials must be closed and locked at all times when the area is unoccupied, regardless of the length of time the area remains unoccupied.

15. RECORDKEEPING

The RSO, Reactor Director, or designee will keep records related to the use of radioactive materials. These records are listed in Appendix F: *Records to be Retained*. The records required by Oregon Administrative Rules include the radiation program (OAR 333-120-0610), surveys and leak tests (-0620), occupational dose (-0630), planned special exposures (-0640), individual monitoring results (-0650), doses to individual members of the public (-0660), waste disposal (-0670), and inventory (OAR 333-102-0910).

PROCEDURES

PROCEDURE 1: SAFE USE OF RADIOACTIVE MATERIALS

OAR 333-102, 333-120

A. GENERAL PROCEDURES

1. Verify that individuals who handle radioactive materials have completed their radioactive materials training and work in areas that have been approved through the principal user application process.

2. Wear personal protective equipment, including the following, when handling radioactive materials other than sealed sources:

   - Lab coats, coveralls, or other means of protecting street clothes.

   - Chemically compatible disposable gloves.

   - Wear closed-toe shoes and long pants or other clothing that covers the legs when working with radioactive materials. Use suitable shoe covers if canvas shoes are worn when working with radioactive liquids.

   - Wear eye protection (safety glasses with side shields, splash goggles) when working with radioactive liquids.

3. Monitor hands and clothing for contamination when using unsealed gamma and beta emitting radionuclides that can be detected with a GM meter. Monitor after completing the procedure and before leaving the area.

4. Never eat, drink, smoke, chew gum, or apply cosmetics/lip balm in areas where unsealed radioactive materials are used or stored.

5. Never store food, drink, or personal effects in areas used for unsealed radioactive material storage.

6. Securely mark, adequately shield, and properly mark radioactive materials transported through hallways. Dispersible radioactive materials require secondary containment (tray, bucket, bag, beaker, etc.) when transported through hallways or within the lab.

7. Wear personnel monitoring devices at all times while in areas where gamma and beta emitting radionuclides with sufficiently high energies are used or stored. When not worn to monitor occupational exposures, store personnel monitoring devices in the work place in a designated low-background area. Do not remove the personnel monitoring devices from the workplace or allow anyone other than the workers to whom they were assigned to wear them.

8. Place radioactive waste only in designated, labeled, and properly shielded receptacles.

9. Never mouth pipet.

10. Conduct regular surveys of work areas using a radiation detection survey meter whenever gamma and beta emitting radionuclides with sufficiently high energies are in use. Results will be recorded on Form 2: Radiation Survey Report as described in Procedure 4: User Surveys.

11. Keep radioactive solutions in their shielded and clearly labeled containers. Labels must include the isotope, amount, name of the compound, other related hazard information (e.g., Radioactive), and the date and time of receipt or preparation. Record data on Form 3: Receipt, Use and Disposal Log.

12. Label all equipment (e.g., pipettes, glassware, automatic pipettors, etc.) used with radioactive materials as such. Do not use them for other purposes until they have been decontaminated.

13. Only individuals who have completed Authorized or Principal User training as described in Procedure 8: Personnel Training can handle radioactive material in labs recognized through a Principal User's application.

B. SPECIFIC PROCEDURES

1. **Tritium (H-3)**: Organic compounds with activity of 10 millicuries (10 mCi, 370 MBq) or more, or inorganic compounds with activity of 50 millicuries (50 mCi, 1.8 GBq) or more:

    - Carry out all work in a hood.

    - Balance activity in waste, product, etc. to account for total starting activity.

    - Inform the RSO before handling organic H-3 in single packages with activity of 10 millicuries (10 mCi, 370 GBq) or more, or inorganic H-3 in single packages of 50 millicuries (50 mCi, 1.8 GBq) or more. Submit to the RSO or designee a urine sample before work begins to establish a baseline, then submit another urine specimen to the RSO within 12-48 hours of opening the container or otherwise using the material. The sample will be analyzed with a liquid scintillation counter, using procedures developed by Oregon State University Radiation Center in their RCHPP 14.

2. **Radioactive Iodine**: For all iodine compounds regardless of activity, unless specified:

    - Carry out all work in a hood.

    - Wear double gloves.

- Double bag all wastes.

- Inform the RSO before handling 1 millicurie (1 mCi, 37 MBq) or more of I-125. Have a thyroid scan performed before work begins to establish a baseline, and again within 24-48 hours of opening the container or otherwise using the material. The RSO will arrange the scan with Oregon Health Sciences University Radiation Safety Lab.

3. **Phosphorus (P-32)**: All Phosphorus-32 compounds regardless of activity:

    - Wear ring dosimetry.

    - Conduct all work behind a plastic shield.

C. ALARA – AS LOW AS REASONABLY ACHIEVABLE

The ALARA philosophy is one of the basic principles of Health Physics. Based on the principle that any dose of radiation, no matter how small, can increase the risk of negative biological effects, it says simply that users must consider the potential risk and the benefit to be gained by each action taken. All actions should be designed to minimize risk (i.e. the radiation dose). This is the case regardless of whether any regulatory limits are approached. Federal and state governments support this philosophy, as well as the Radiation Safety Committee for work at Reed College.

D. HISTORICAL RADIATION EXPOSURES

The highest annual whole-body radiation exposure at Reed was about 200 mrem (well under the 10CFR20 limit of 5000 mrem) and was received by the Reactor Health Physicist while performing an operation requiring close handling of a very large source. Only a few individuals have received whole-body exposures of more than 100 mrem per year; most have been far below that, and many have recorded whole-body exposures of zero. There is no reason why doses cannot be kept just as low in the future.

E. WHAT TYPES OF ACTIONS CONSTITUTE ALARA ACTIONS?

The following are examples only. Think about your work, and use your knowledge, background, and imagination.

- When samples are irradiated in the reactor, they are to be left in the rotary specimen rack until either the experimenter needs the samples or the reactor needs to be prepared for other purposes. Earlier removal will inherently result in higher radiation doses without added benefit.

- If you are carrying a radiation source and someone asks you a question, set the source down in a safe place and step back until your conversation is completed. Preferably, delay the conversation until the source is secured at its intended destination.

- When handling radioactive samples, use tongs or place them in wooden blocks. Remember that most of these materials are beta emitters. The range of beta particles in material of unit density (i.e., 1 g/cm3) is about 1 cm. If the first centimeter is part of your finger, doses will be high; if it is wood, your beta dose may be very close to zero.

- Work efficiently, NOT hastily. The longer it takes to do a job, the higher the dose, BUT the need to redo a job or to clean up a spill resulting from hasty work can significantly INCREASE total dose.

- PLAN AHEAD! This is the most important ALARA aid. Discuss the entire operation with your coworkers before you begin. Know exactly who is responsible for what. If possible, conduct a dry run with non-radioactive material until the operation runs smoothly. If anything goes wrong during the actual operation, do not panic. Simply set things down gently, back off, and regroup.

F. PERSONNEL MONITORING

The following specific actions will help ensure ALARA.

- Anyone who enters a High Radiation Areas (> 100 mrem/hr at 30 cm from source) must wear personally issued whole body (badge) and extremity (ring) dosimetry. A temporarily issued Electronic Personal Dosimeter (EPD) is not sufficient. (See OAR 333-120-0210 (1) (d).)

- Any operation which has the potential to expose an individual to a whole-body dose of 10 mrem shall be performed by or under the direct supervision of the Principal User, Radiation Safety Officer, Reactor Director, or Operations Manager.

- Any whole body dose in excess of 50 mrem in a quarter or an extremity dose in excess of 100 mrem in a quarter shall be investigated by the Radiation Safety Officer.

PROCEDURE 2: EMERGENCIES

OAR 333-120-0720

A. DEFINITIONS

1. A **minor spill** of radioactive materials is defined as less than 50 microcuries (μCi) or about 1.11×10^7 counts per minute (assuming efficiency = 10%) and presents little to no radiation or other hazard to personnel or the environment.

2. A **major spill** of radioactive materials is defined as more than 50 microcuries (μCi) or about 1.11×10^7 counts per minute (assuming efficiency = 10%) In addition, if someone is injured or the spill poses a significant threat to the safety and health of employees in the immediate vicinity or the environment, it is a major spill.

NOTE: $50\ \mu Ci \times \frac{2.22 \times 10^6\ dpm}{1\ \mu Ci} \times efficiency_{detector} = cpm_{\geq bkgd}$

B. MINOR SPILLS

1. Immediately notify all other persons in the room.

2. Confine the spill and clearly mark the boundary of the spill.

3. Survey yourself and all other persons in the vicinity. Decontaminate personnel before equipment or surfaces. For ALARA reasons, DO NOT stand near the spill and be careful to avoid spreading contamination.

4. Limit access to the contaminated area to people aiding in cleanup. Do this by locking doors or posting signs and/or individuals at laboratory entrances.

5. For liquid spills:

    - Don two layers of protective gloves, eye protection, and other personal protective equipment per Procedure 1, section A.

    - Cover spill with absorbent paper or use lab spill kit.

6. For dry spills:

    - Don protective gloves.

    - Cover spill with damp absorbent paper, taking care not to spread the contamination.

    - Decontaminate per Procedure 2 section J (Decontamination).

- Notify the Radiation Safety Officer (RSO).
- Permit no person to resume work in the area until a survey is done.

C. MAJOR SPILLS

1. Notify all persons not involved in the spill to vacate the room at once. Alert the nearest person to contact the RSO.
2. If the spill is liquid and hands are protected, right the container. Work to avoid personal contamination, prolonged exposure, or spread of the spill. Consider the potential for airborne radiation. Cover the contaminated area and an additional two foot perimeter with absorbent paper and clearly mark a clean line unless hazardous to do so.
3. Step away from the work area to lower radiation dose rate.
4. Survey yourself and other personnel involved thoroughly.
5. Evacuate the room. If possible, survey personnel before evacuation. Do not spread contamination outside of the lab.
6. Prevent access to the room by locking doors or posting signs and/or individuals at laboratory entrances.
7. Take immediate steps to decontaminate personnel involved as necessary.
8. Survey all personnel and areas adjacent to the lab. Consider using an air monitor to identify airborne contamination. Control the spread of contamination outside of the lab and decontaminate if necessary.
9. Perform decontamination under the supervision of the RSO or other qualified personnel designated by the RSO. Perform bioassay if required by Policy Section 3B: Bioassay Program.
10. Permit no person to resume work in the area until a survey is completed and approval of the RSO is obtained.
11. Write a complete history of the accident and subsequent activity for the laboratory records, using Form 6B: Contamination Report.

D. SKIN CONTAMINATION

1. Begin decontamination as soon as possible. Use mild soap and tepid water. Wash the affected area several times. Do not scrub, as strong scrubbing will abrade the skin, which can lead to increased penetration of the contamination.
2. Have the nearest non-contaminated person (if available) contact the RSO.

3. If hair becomes contaminated, immediately wash with soap and water. Because hair can very easily spread contamination, take care that hair does not come in contact with anything else.

4. Make note of initial and subsequent contamination levels. Save wash water for analysis.

5. Write a complete history of the accident and subsequent activity for the laboratory records, using Form 6B: Contamination Report or reactor form SOP 50A: Personnel Contamination Form.

E. EYE CONTAMINATION

1. Flush eyes thoroughly (approximately 15 minutes) with isotonic solution (if available), otherwise, use water. Roll the eyelid back as far as possible.

2. Seek medical attention.

3. Notify RSO.

4. Write a complete history of the accident and subsequent activity for the laboratory records, using Form 6B: Contamination Report or reactor form SOP 50A: Personnel Contamination Form.

F. NOSE OR MOUTH CONTAMINATION

1. Immediately flush nose and mouth with water. Take care not to ingest the rinse.

2. Notify RSO.

3. Write a complete history of the accident and subsequent activity for the laboratory records, using Form 6B: Contamination Report or reactor form SOP 50A: Personnel Contamination Form.

G. CLOTHING CONTAMINATION

1. Promptly remove contaminated clothing to minimize dose. Take care not to allow the outside of the clothing to come in contact with skin.

2. Contact the RSO or Reactor Director to obtain uncontaminated, clean clothing.

3. Record contamination levels of clothing to allow calculation of potential skin dose to the individual. Place the contaminated clothing in a plastic bag and give it to the RSO or Reactor Director for cleaning or disposal.

4. Write a complete history of the accident and subsequent activity for the laboratory records, using Form 6B: Contamination Report or reactor form SOP 50A: Personnel Contamination Form.

H. SHOE CONTAMINATION

1. Contact the RSO or Reactor Director for a pair of disposable booties. Do not walk in contaminated shoes since this will spread the contamination

2. When the shoes are covered, walk to a sink, remove shoes, and clean the soles with soap and water.

3. Survey the area to find the parts of the floor that are contaminated and clean them per Procedure 2 section J (Decontamination).

4. Write a complete history of the accident and subsequent activity for the laboratory records, using Form 6B: Contamination Report or reactor form SOP 50A: Personnel Contamination Form.

I. RELEASE OF AIRBORNE OR VOLATILE RADIOACTIVITY

1. Alert everyone in the vicinity of the release; keep unneeded persons out of the affected area.

2. Evacuate the room and take whatever steps to contain the contamination that can be done safely and immediately, e.g. close windows and doors, turn off fume hood.

3. Contact the RSO or Reactor Director.

4. Request that evacuees remain nearby until cleared by RSO or designee.

5. Check all people who were in the area at the time of the release for contamination. If/when contamination is found, decontaminate per Procedure 2, section G (Clothing Contamination) above.

6. If/when contamination is found in the room, begin decontamination at the nearest sink following the steps below.

7. Write a complete history of the accident and subsequent activity for the laboratory records, using Form 6B: Contamination Report.

J. DECONTAMINATION

1. Supplies:

   - Plastic garbage bags.

   - Colored tape.

   - Disposable absorbent material.

   - Cleaning detergents (Simple Green works well).

- Bucket for water (if needed).

- Protective clothing (possibly several layers) including booties, gloves, and safety glasses. If the spill is liquid, the protective suits should be plastic-backed.

- Appropriate meter (such as a GM meter) and wipes.

2. Pre-decontamination:

   - Secure area from traffic. Locate and mark off all contaminated areas. Draw a map of the room or area marking contaminated areas if needed.

   - For H-3 spills, wear booties and gloves and take wipes of the room for analysis in the liquid scintillation counter (LSC) in order to determine the areas of contamination.

   - Don protective clothing. 2-3 pairs of gloves and booties may be necessary.

   - Survey just outside the contaminated room with a GM meter to ensure the contamination has not spread.

3. Decontamination:

   - Start cleaning at the edge of the contaminated area and work inward.

   - Absorb standing liquids.

   - Apply cleaning solution. Leave for 1-2 minutes.

   - Wipe up the solution moving the wipe stroke inwards, thus continually reducing the borders of the contamination.

   - Use damp absorbent paper to wipe up dry or powder contamination.

   - Place used cleaning rags/materials in a plastic garbage bag, marked with a Radioactive Material sticker.

   - Do not remoisten absorbent paper. Do not allow cleaning solution to spread to non-contaminated areas (e.g., drip over clean lines).

   - Only use absorbent materials and rags once.

   - Survey areas that have been cleaned to see if the contamination was removed. Continue cleaning until all contamination is removed.

- Survey and change decontamination clothing as needed and frequently (especially gloves).

- Remove and replace torn clothing immediately.

4. Cautions:

   - Do not use hot water to clean H-3, C-14, or I-125 because they may vaporize.

   - Do not use detergents that contain acids to clean iodine spills because reactions may produce toxic gases.

PROCEDURE 3: SEALED SOURCE LEAK TEST

OAR 333-120-0460

A. SEALED SOURCE INVENTORY

A list of sealed sources is on file with the RSO. Sources that need to be wipe tested are listed in Appendix C: *Sealed Sources to be Leak Tested.*

B. FREQUENCY OF TESTING

Sealed sources will be tested every 6 months with the following exceptions:

- Alpha emitters used for their alpha emissions, which are greater than 10 microcuries (10 μCi, 370 kBq), will be tested every 3 months.
- Alpha emitters less than or equal to 10 microcuries (10 μCi, 370 kBq) need not be tested.
- Sources containing only gas or tritium need not be tested.
- Sources that are in storage and not in use need not be tested. Sources meeting these criteria must be tested prior to being put back in use. Notify the RSO whenever this occurs.
- Sources which contain less than or equal to 100 microcuries (100 μCi, 3.7 MBq) of a beta or gamma emitting material need not be tested.
- Sources should be leak tested within 24 hours if there is reason to suspect their integrity (i.e., damage).

C. PROCEDURE

1. The reactor's wipe test procedure, SOP 51, describes how to measure removable radioactive contamination. SOP 51 can be found in the reactor office (Chemistry 102). Take a cotton swab, wipe it on the surface of the source, and count it in a detector. For alpha sources, wipe areas near the source (such as the case) rather than the source itself to prevent damage to the source. Wear disposable gloves when taking wipes.

2. A source is considered to be leaking if greater than 185 Bq (0.005 μCi) of contamination is measured.

3. As of October 2012, the normal wipe test counter is a Perkin-Elmer Tri-Carb 2900 Liquid Scintillation Counter. If necessary, it is permissible to use a different calibrated detector capable of measuring beta-gamma radiation.

   For alpha wipes, the swab is also counted with a detector capable of detecting alpha radiation, such as a Thermo E-600.

4. The wipe test counter is calibrated annually, not to exceed 65 weeks. The wipe test counter is tested for quality control each day a wipe test is performed by measuring a check source and background. The Reactor Safety Committee audits the procedure every two years.

PROCEDURE 4: USER SURVEYS

A. AMBIENT EXPOSURE RATE SURVEYS

1. Conduct surveys with a radiation detection survey meter appropriate for the radionuclide. Record the results of these surveys on Form 2: Radiation Survey Report at least bi-weekly (interval not to exceed 19 days) and whenever unexpected readings occur.

2. In storage and waste storage areas: survey at least once a month (interval not to exceed 40 days) with a radiation detection survey meter. Record results on Form 2: Radiation Survey Report.

3. In sealed source storage areas: survey at least once a month (interval not to exceed 40 days) with a radiation measurement survey meter. Record results on Form 2: Radiation Survey Report.

4. If a higher than expected reading occurs in the survey, and contamination is suspected, a wipe test must be conducted and counted using a detector appropriate for the nuclide to determine if there is removable contamination. Results must be recorded on Form 2: Radiation Survey Report.

B. REMOVABLE CONTAMINATION SURVEYS

1. If tritium, carbon-14, or sulphur-35 is used, bi-weekly wipe tests are required (interval between wipe tests not to exceed 19 days). Use the liquid scintillation counter for these tests and record on Form 2: Radiation Survey Report.

2. When low energy beta emitting radionuclides are in storage, at least once a month (interval not to exceed 40 days) wipe tests are required. These tests must be counted in a liquid scintillation counter and recorded on Form 2: Radiation Survey Report.

3. If higher than expected counts occur in the ambient exposure rate survey (Procedure 4 section A), conduct another wipe test and count using a nuclide-appropriate detector to determine if the contamination is removable. Record results on Form 2: Radiation Survey Report.

4. The wipe sample assay procedure should be sufficiently sensitive to detect the presence of 200 dpm/100 cm^2 of removable contamination. A radioactive source with a known amount of activity must be used to convert sample measurements (usually in counts per minute) to microcuries (μCi).

5. Records of wipe tests must be retained.

6. Wipes of the reactor facility are performed biweekly. Source wipes are performed during routine leak tests. Special wipes are performed during other activities: transportation, contamination events, outside users, etc.

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PROCEDURE 5: WASTE DISPOSAL

OAR 333-120-0500, 0520, 0540, 0550, 0560

A. SINK DISPOSAL

1. Liquids may be released to the sanitary sewer with permission of the Radiation Safety Officer. This does not relieve the user from complying with other regulations regarding toxic or hazardous properties of these materials.

2. Rules for disposal in the sanitary sewer appear in OAR 333-120-0520. Material must be readily soluble or dispersible in water. The quantity of licensed or other radioactive material allowed to be released in to the sewer in one month is shown in Appendix D: *Sewer Disposal Limits*. These maximum monthly quantities have been calculated by multiplying the limits listed in 10 CFR 20 Table 3 of Appendix B 20.1001 to 20.2401 by the average monthly volume of water released into the sewer at Reed College.

3. Register the sink used for sewer disposal with the Radiation Safety Officer (RSO). Post a "Caution – Radioactive Material" sign at the sink. Only sinks registered with the RSO may be used for sink disposal.

4. Record the following information: date, radionuclide, estimated activity that was released (in millicuries, mCi, or microcuries, μCi), estimated concentration, site at which the material was released, and initials of individual making the disposal on Form 4: *Sink Disposal Log*. Disposal must also be recorded on Form 3: *Receipt, Use, and Disposal Log*.

5. Flush the sink profusely with water *for at least five minutes*, continuing until the material is washed from the sink. Survey the sink to verify that the sink has been cleaned of all detectable radioactive material.

6. Change disposal logs as needed. Send a copy of the old log to the RSO when it is changed. The RSO may request a copy of the log at any time. Disposal must also be recorded on Form 3: *Receipt, Use, and Disposal Log*.

B. DISPOSAL BY DECAY-IN-STORAGE

1. Dispose of short-lived material (physical half-life less than 90 days) by decay-in-storage.

2. When possible, separate waste by radionuclide so that shorter-lived wastes can be stored only as long as necessary for radiation to decay to background levels.

3. Absorb liquids onto vermiculite, clay absorbent, or other material so that no free liquids remain. This reduces the possibility of spills during storage.

4. Use plastic double-bags for materials to be decayed-in-storage and seal the bags tightly. Label all materials with the following information (labels are available from the RSO):

    - Radionuclide and approximate activity.
    - Date.
    - Chemical compound(s) contained in the waste and appropriate hazard information.
    - Room where the waste was generated.
    - Name of person preparing package.

5. After packaging decay-in-storage materials, contact the RSO to schedule a waste pick up. Record disposals on Form 3: Receipt, Use, and Disposal Log. The material will be decayed for at least 10 half-lives. Before release to trash, monitor the material using the appropriate radiation detection device. Wastes must have radioactivity levels that are indistinguishable from background in order to be disposed of in the regular trash. Remove or deface all radioactive materials labels before disposal in the regular trash.

6. Prior to disposal, the RSO or designee will label the waste and record the following information on Form 5: Decay-in-Storage Log:

    - Activity at time of disposal.
    - Date.
    - Initials of individual conducting the survey.

C. TRANSFER FOR BURIAL

1. Except for material suitable for decay-in-storage and some animal carcasses, transfer solid wastes with a half-life greater than 90 days to a burial site

2. Place waste materials in double-bagged and tightly sealed plastic bags. Label the materials with the following information (labels are available from the RSO):

    - Radionuclide and approximate activity.
    - Date.
    - Chemical compounds(s) contained in the waste and appropriate hazard information.
    - Room where the waste was generated.

- Name of person preparing the package.

3. After packaging materials for transfer to a disposal site, contact the RSO or Reactor Director to schedule a waste pick up. Record disposals on Form 3: Receipt, Use, and Disposal Log.

4. The RSO or Reactor Director will arrange for disposal at a secure burial site through a commercial waste disposal service and will oversee compliance with all applicable DOT and NRC regulations concerning labeling, packaging, and transportation of radioactive wastes.

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PROCEDURE 6: RADIOACTIVE MATERIALS PACKAGE ORDERING AND RECEIPT

OAR 333-120-0450; OAR 333-118-0150

A. PROCUREMENT AND AUTHORIZATION

Radiation Safety Officer (RSO) must approve each request for purchase of radioactive materials before the placement of the order. It is the responsibility of the Principal User to obtain RSO authorization to place an order to purchase radioactive materials. When the order is placed, the Principal User will notify the mailroom (mail-services@lists.reed.edu) and the RSO of the intended date of receipt.

B. RECEIPT

1. Upon receipt of packages containing radioactive materials, the mailroom will contact the RSO and the Principal User. The Principal User will either pick the package up from the mailroom or make specific delivery arrangements with the mailroom. The Principal User must contact the RSO and provide the following information: radioisotope, chemical form, activity, supplier, and purchase order number.

2. Only the Principal User may open and survey packages of radioactive materials. This must be done within three hours of receipt.

C. SURVEY (EXCLUDING TRITIUM OR CARBON-14)

1. Assume any package received is contaminated until thoroughly surveyed.

2. The individual receiving the package must wear a dosimetry badge and finger ring. Gloves must be worn over the ring, with the ring's dosimeter on the palm-side of the finger.

3. Place the package on absorbent paper in a fume hood. If a fume hood is unavailable and the material is sufficiently low in activity to use outside of a hood, simply place package on absorbent paper.

4. After turning the survey meter ON, measure the radiation level at one meter from the surface of the package. The reading (in mrem/hr) should agree with the transport index (TI) indicated on the label (e.g., a dose rate of 2.6 mrem/hr is a TI of 2.6). If the reading is higher, assume the integrity of the package is broken. Record all readings on Form 3: Receipt, Use, and Disposal Log. Use an ion chamber or microR meter for this measurement unless you have a GM meter that is calibrated for use with the particular isotope being measured.

5. Move the survey meter far enough away from the package to take a background reading.

6. Check gloves with survey meter. If not contaminated, wipe 300 cm^2 of the package with a tissue or filter paper. A good place to take the wipe is a seal, edge, seam, etc.

7. Using a GM meter, survey the wipe by placing it next to the meter probe. If the reading is indistinguishable from background, open the package and wipe the inner container using the same procedure as above. Survey the second wipe using the same procedure. Record all readings on Form 3: Receipt, Use, and Disposal Log.

8. Deface all radioactive materials labels on uncontaminated packaging before disposal.

9. The shipping label gives the amount of material in becquerel (Bq). Make the calculation to determine if this agrees with what was ordered. One Bq equals one disintegration per second. One Curie equals 3.7 x 10^{10} dps, which is 37 gigabecquerel (GBq).

10. If readings greater than 1000 dpm above background are found in any of the above steps, carefully clean the outside of the container before use. Double bag all contaminated material for disposal as radioactive waste. Inform the RSO.

D. SURVEY FOR TRITIUM OR CARBON-14

1. Assume any package received is contaminated until thoroughly surveyed.

2. Don protective gloves and safety glasses.

3. Place the package on absorbent paper in a fume hood. If a fume hood is unavailable and the material is sufficiently low in activity to use outside of a hood, simply place package on absorbent paper.

4. Perform a wipe of 300 cm^2 on the outside of the package. Analyze using a liquid scintillation counter (LSC). Record all readings on Form 3: Receipt, Use, and Disposal Log.

5. If no contamination is found on the outside of the package, open the package and perform wipe test on the inside of the package and on the container. Analyze using a LSC. Record all readings on Form 3: Receipt, Use, and Disposal Log.

6. Deface all radioactive materials labels on uncontaminated packaging before disposal.

7. If readings greater than 1000 dpm above background are found in any of the above steps, carefully clean the outside of the container before use. Double bag all contaminated material for disposal as radioactive waste. Inform the RSO.

PROCEDURE 7: CLOSE-OUT AND DECOMMISSIONING

OAR 333-102-0310

A. CLOSE-OUT PROCESS

1. The RSO or designee will carryout the close-out process in areas where radioactive material will no longer be used.

2. Close-Out Survey

   - Thoroughly survey the laboratory using a GM meter if appropriate. Use Form 2: Radiation Survey Report to record findings.

   - Perform a survey and/or wipe tests of equipment, to determine if removable contamination is present. Analyze using a liquid scintillation counter or other appropriate counting equipment.

   - Perform a wipe test of the sink drainpipe and/or floor drain if there is one. Use tongs or other device to ensure that the wipe sample is taken from fairly deep within the drain.

   - Perform a survey and/or wipe test in adjacent laboratories/rooms and equipment to check for spread of contamination or unauthorized use.

3. Waste Removal

   - Use Form 3: Receipt, Use and Disposal Log to balance the radioactive materials inventory for the lab.

   - Dispose of all waste materials in accordance with Procedure 5: Radioactive Waste Disposal Procedures.

4. If any contamination is found, thoroughly clean the area and retest. Repeat until laboratory is free of contamination.

5. When all radioactive materials and waste have been removed from the lab and surveys indicate that no contamination is present, remove all radioactive materials labels from the laboratory door, equipment, and work benches.

6. The Principal User will forward final records of any laboratory decontamination, radioactive materials disposal, and inventory balance to the RSO. The RSO will inspect the lab and send a memo to the Principal User and the chair of the Radiation Safety Committee documenting that the lab is closed out.

B. DECOMMISSIONING PROCESS

1. The RSO or designee will provide a decommissioning plan pursuant to OAR 333-102-0310 before license termination that includes the following:

    - Description of the site.
    - Planned decommissioning activities including levels of risk and safety concerns.
    - Methods used to protect workers and the environment from radiation during decommissioning.
    - Description of planned final radiation survey.
    - Estimate of costs and plan for ensuring availability of funds.

2. The RSO or designee will certify the disposition of all licensed materials by submitting NRC Form 314 or an equivalent.

3. Decommissioning must be completed and license termination requested as soon as practicable and within 24 months after decommissioning begins.

4. Survey

    - Carry out a final survey of the places where licensed materials were used.
    - Submit a report that includes levels of gamma radiation per hour at one meter from surfaces; levels of radioactivity (alpha, beta, and gamma) per 100 square centimeters on surfaces, per milliliter in water, and per gram for solids; and survey instruments used.

5. Records to be forwarded to the Oregon Health Authority before license termination.

    - Records of disposal of licensed material (OAR 333-102-0355).
    - Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment (OAR 333-120-0620(2)(d)).

PROCEDURE 8: PERSONNEL TRAINING

A. PRINCIPAL USERS

1. Principal Users (training outlined on in Policy 13.b) are typically faculty or staff who supervise a lab using radioactive materials, such as Faculty, Researchers, the Reactor Director, the Reactor Operations Manager, the Radiation Safety Officer, or the Assistant Radiation Safety Officer.

2. Principal Users must pass (80%) the examination under the same conditions as Authorized Users (below).

3. All new Principal Users will be supplied with a copy of the Reed College Radioactive Materials Policy and Procedures Manual, the Reed College Radioactive Materials Handling Study Guide, and a copy of the U.S. Nuclear Regulatory commission Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure.

4. If the Principal User has documentation of training and use of radioactive materials at another institution, no further training is required. If no such documentation exists, the Principal User must follow the procedure for new Authorized Users (below) to become authorized.

5. The Principal User must complete Form 8: Application for Use of Radioactive Materials and submit it to the Radiation Safety Committee for approval before radioactive materials may be used in the laboratory.

6. The Principal User must renew his/her Application for Use of Radioactive Materials every three years. If the procedure for use has not changed significantly, the Principal User can review his/her present application and resubmit it for review by the Radiation Safety Committee.

7. Any significant changes in procedures require the Principal User to submit a new application for approval by the committee.

B. AUTHORIZED USERS

1. Authorized Users may be students, non-Reed employees, visitors, or others who use radioactive materials under the direction of a Principal User.

2. All new Authorized Users must take and pass (80%) a radioactive materials authorization examination provided by the RSO. The Authorized User trainee may only take the test three times without further committee approval. There must be a period of five days between the first and second attempt and a period of ten days between the second and third attempt of the test. The Radiation Safety Committee must approve further attempts at the test.

3. All new Authorized Users must be assigned to work with a Principal User.

4. Before the Authorized User may begin work with radioactive materials, the Principal User will train the Authorized User to use a scintillation counter (if applicable) and/or in safe laboratory use of radioactive materials. Before the Authorized User's authorization is complete, a signed Certificate of Authorized User Training (Form 7) must be received by the RSO.

5. Authorized User trainees must watch three video tapes (QC41.R33 1982 VIDEO, located in the Reed College IMC; or equivalent radiation safety videos) before taking the authorization examination. The video tapes pertain to Principles of Radiation, Laboratory Safety, and Emergency Procedures.

6. The Authorized User trainee will receive a copy of the Reed College Radioactive Materials Policy and Procedures Manual and a Radioactive Materials Handling Study Guide to prepare for the examination.

C. ANCILLARY PERSONNEL

Those employees whose duties may bring them in the vicinity of radioactive materials (e.g., security, maintenance, and custodial personnel) will receive training triennially in the following topics as part of their Right-To-Know training:

- Locations where radioactive materials are stored.
- Overview of the *Reed College Radioactive Materials Policy and Procedures Manual* as it pertains to the survey and wipe testing of work areas.
- Procedures for entry into areas where radioactive materials are used.
- Recognition of radioactive materials labels.

D. REFRESHER TRAINING

A triennial overview of Reed College Radioactive Materials Policy and Procedures will be presented to all active Principal Users. Inactive Principal Users will receive refresher training before resuming use of radioactive materials. Authorized Users and ancillary personnel will receive refresher training triennially (interval not to exceed 190 weeks) including a new exam to verify continued competence. Additional refresher training will be required whenever significant changes to duties, rules, or the terms of the license occur.

FORMS

FORM 1: SEMI-ANNUAL INVENTORY LOG

Principal User: _____ Date: _____

ID Number	Nuclide	Quantity	Chemical Form	Location

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FORM 2: RADIATION SURVEY REPORT

Date: _____ Location: _____ Principal User: _____

Prepared By (print name): _____

Survey Instrument: _____ ___ All dose rates < 0.10 mR/hr

Inspector's Comments:

_____

_____

_____

RAM Present? (If no, stop here and x-out rest of form to signature): _____

Measurements Circle: Y = Yes N = No N/A = Not Applicable

Y / N / NA Meter check for external dose rates and contamination of surfaces (hot sinks, hoods, storage areas, refrigerators).

Y / N / NA Wipe tests of all suspected areas of contamination (sink ledge, hood ledge, bench top) plus check of "clean areas."

Y / N / NA Air sampling (where required)

Inspection

Y / N / NA State of Oregon Form posted.

Y / N / NA Institutional regulations (or Alternate Notice) posted.

Y / N / NA Proper signs (radiation area, radioactive material) posted.

Y / N / NA Storage area controlled, posted, and secured. Y / N / NA Radioactive Mat'l present

Y / N / NA Waste disposal area controlled and posted. Y / N / NA Waste present

Y / N / NA Hood flow satisfactory.

Y / N / NA Sources, waste solutions, etc., properly labeled. Y / N / NA Sources present

Y / N / NA Sink disposal records posted and up to date.

Monitoring Instrumentation

Y / N / NA Available (Type and model_____)

Y / N / NA Performance check _____ Date of last calibration

Review of Handling Procedures

Y / N / NA Personnel monitoring devices worn (whole body and hands).

Y / N / NA Records of monitoring kept.

Y / N / NA No pipetting by mouth observed.

Y / N / NA Protective clothing utilized, including gloves, coats.

FORM 2: RADIATION SURVEY REPORT

Background dose rate:
_____ mR/h
Background count rate:
_____ cpm
All contamination surveys <100 cpm above background? Y / N

[Area diagram here]

REMOVABLE CONTAMINATION

	Location	Net μCi/100 cm² H-3	Net μCi/100 cm² C-14	Net μCi/100 cm² P-32	Total DPM
	Background	×10⁻	×10⁻	×10⁻	
1		×10⁻	×10⁻	×10⁻	
2		×10⁻	×10⁻	×10⁻	
3		×10⁻	×10⁻	×10⁻	
4		×10⁻	×10⁻	×10⁻	
5		×10⁻	×10⁻	×10⁻	
6		×10⁻	×10⁻	×10⁻	
7		×10⁻	×10⁻	×10⁻	
8		×10⁻	×10⁻	×10⁻	
9		×10⁻	×10⁻	×10⁻	
10		×10⁻	×10⁻	×10⁻	

Contamination found: Y / N Counter Used: Perkin Elmer Tri-Carb 2900 Liquid Scintillation Counter
Date: _____ Signature of Inspector: _____

Reviewer's Comments:

_____

_____

_____

Date: _____ Reviewed by: _____

FORM 3: Receipt, Use, and Disposal Form

(Indicate units of measurement)		
PI:	**Lab location:**	
RSO approval: **Signature:**_____ **Date:**_____		
Mailroom notified (at mail-services@list.reed.edu) ☐	**Date ordered:**	
Isotope:	**Date Received:**	**P.O. number:**
Chemical form:	**State of Matter: S L G (circle one)**	**Use in aliquots:**
Initial Activity Date*:	**Initial Activity****	**Initial Volume:**
*Initial activity date on packing slip and initial activity should be used for decay calculations. ** Initial activity is indicated on packing slip as "total activity" which may be different than quantity ordered. For example: 1.47 millicuries of P-32 is usually shipped when only 1 millicurie was ordered.		

Wipe Test: Package Receipt (Please indicate units of measurement)	
Transportation Index (TI):	Meter Reading @ 1 meter:
Package Outside:	Package Inside:
Source container outside:	Performed by:
Contact RSO (x7788) if contamination levels exceed 1000 dpm/100 cm^2 ($4.5x\ 10^{-4}$ μCi/100 cm^2). Clean thoroughly if contamination is above background.	

	USE						
Date	Withdraw	Decay	Drain	RSO	Misc.	Balance	Initials

Move to decay-in-storage ____ or to RSO or designee ____. Date: _____

Signature: _____ Contamination action level: 1000 dpm/100 cm^2 (4.5×10^{-4} μCi/100 cm^2)

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FORM 4: SINK DISPOSAL LOG

Principal User: _____ **Sink Site:** _____

Date of Disposal	**Radionuclide**	**Activity** (mCi or cpm)	**Detector Efficiency** (if cpm used)	**Volume**	**Estimated Concentration**	**Initials**

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FORM 5: DECAY-IN-STORAGE AND DISPOSAL LOG

Into Decay-in-Storage						Disposal				
Date into Storage	Isotope	Description	Initial dpmll	Bkg dpm	Initials	Disposal dpm	Bkg dpm	≤ bkg (Y/N)	Date of Disposal	Initals

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FORM 6A: CONTAMINATION LOG

Incident Number*	Location	Date	Highest cpm > background	Results of Decontamination

Remember, this form is used in case of a major spill. Here is the conversion from cpm to μCi:

$$\frac{cpm_{>bkgd}}{efficiency} \times \frac{1\,\mu Ci}{2.22\times10^{6}\,dpm} = \_\_\_\_\ \mu Ci$$

***** Assigned by RSO or designee.

FORM 6B: CONTAMINATION REPORT

Incident Number*: _____ Date: _____Location:_____ Individual:_____
Record the location and severity of the contamination/spill below. Number each survey location on the map, and highlight or circle the contaminated area.

Prepared By (print name):		
Survey Instrument:		
Background (cpm):	cpm > Background	
	Before Clean-up	After Clean-up
1		
2		
3		
4		
5		
6		
7		
8		

Describe how the spill/contamination happened (use additional sheets as needed):

_____

_____

_____

_____

_____

Actions taken / results of decontamination (use additional sheets as needed):

_____

_____

_____

_____

_____

Date: _____ Signature: _____

Date: _____ RSO Reviewed: _____

***** Assigned by RSO or designee.

FORM 7: PERSONNEL TRAINING FORM

1. NEW AUTHORIZED USERS

- All new Authorized Users must take and pass a radioactive materials authorization examination provided by the RSO.
- All new Authorized Users must be assigned to work with a Principal User (PU).
- Before the Authorized User may begin work with radioactive materials, the PU will train the Authorized User in safe laboratory use of radioactive materials and to use a scintillation counter (if applicable).
- Before the Authorized User's authorization is complete, a signed Certificate of Training must be received by the RSO.
- Authorized User trainees must watch three video tapes (QC41.R33 1982 VIDEO, located in the IMC; or equivalent radiation safety videos) before taking the authorization examination. The videotapes pertain to Principles of Radiation, Laboratory Safety, and Emergency Procedures.
- The Authorized User trainee will be supplied with a copy of the Reed College Radioactive Materials Policy and Procedures Manual and a Study Guide to prepare for the examination.

2. NEW PRINCIPAL USERS

- New Principal Users must take and pass a radioactive materials authorization examination provided by the RSO.
- All new Principal Users will be supplied with a copy of the Reed College Radioactive Materials Policy and Procedures manual.
- If the PU has documentation of training and use of radioactive materials at another institution, no further training is required. If no such documentation exists, the PU must follow the procedure for new Authorized Users (above) to become authorized.
- The PU must complete Form 8: Application for Use of Radioactive Materials and submit it to the Radioactive Materials Committee for approval before RAM may be used in the laboratory.

3. ANCILLARY PERSONNEL

- Those employees whose duties may bring them in the vicinity of radioactive materials (e.g., custodial work, maintenance, security) will receive training in the following topics as part of their Right-To-Know training:
    - Locations where radioactive materials are used or stored.
    - Overview of Reed College Radioactive Materials Policy and Procedures Manual as it pertains to the survey and wipe testing of work areas.
    - Procedures for entry into areas where radioactive materials are used.
    - Recognition of radioactive materials labels.
- Ancillary personnel must take and pass a radioactive materials examination provided by the RSO.

4. REFRESHER TRAINING

A triennial overview of Reed College Radioactive Materials Policy and Procedures Manual will be presented to all active Principal Users. Inactive Principal Users shall review relevant materials before renewed use of radioactive materials. Authorized Users and ancillary personnel will receive refresher training triennially (interval not to exceed 190 weeks). All users will receive refresher training whenever significant changes to duties, rules, or the terms of the license occur.

Certificate of Authorized User Training

_____, who will be working with _____
(First, MI, Last) (isotopes)

under the guidance of _____, has completed
(Principal User)

the following requirements for authorization to use radioactive materials:

Authorized User Responsibilities:

Received and read RAM Policy Manual and Procedures

Received and read Study Guide

Watched the videos (QC41.R33 1982 VIDEO, or equivalent radiation safety videos.)

I have reviewed and I understand the materials concerning radiation safety that were presented to me in preparation for the Authorized User examination. The completed examination was reviewed with me and I understand any of the errors I may have made.

I acknowledge the receipt of a copy of the U.S. Nuclear Regulatory Commission Regulatory Guide 8.13 Instruction Concerning Prenatal Radiation Exposure. I have read this document and have had the opportunity to discuss any questions I may have about its contents.

Authorized User Signature _____ Date: _____

Reed I.D. Number _____ Date of birth: _____

Local address or box #: _____

_____

Principal User Responsibilities (Supervisor):

Before beginning work with radioactive materials, the Authorized User will be trained in the use of a scintillation counter (if applicable).

Before beginning work with radioactive materials, the Authorized User will be trained in safe laboratory use of radioactive materials

PU Signature _____ Date: _____

RSO Responsibilities:

Passed the exam _____%

Dosimetry ordered as needed if using gamma emitters (previous radiation history requested)

RSO Signature _____ Date _____

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FORM 8: APPLICATION FOR USE OF RADIOACTIVE MATERIALS

1. Personnel: **Name** **Reed Ext.**

Faculty: _____

Staff: _____

Authorized Users: _____

_____

_____

2. Location (building and room #)

Storage: _____

Use: _____

Sink disposal: _____

3. Nature of Program

Research: _____

Instructional: _____ **Course number:** _____ **Duration:** _____

4. Materials

	Radionuclide	Molecular Form	Maximum amount to be held (mCi)	Currently on hand (mCi)
1				
2				
3				
4				

5. General nature of experimental procedure and hazard evaluation procedures.
Emphasize the procedures involving the handling of radioactive materials rather than on the general scientific approach. Give a detailed description of all intended actions involving radioactive samples. Use additional sheets if necessary.

6. Methods of Disposal

According to Procedure 5: *Waste Disposal*, the following procedures apply to radioactive materials disposal. Please check those that apply to the specific waste stream generated by materials related to this application.

_____ **Liquids:** Release to sanitary sewer if carrier medium is not a hazardous material. Monthly sink disposal limits are listed in Appendix D and are based on total water flow through campus per month. Sink must be authorized by RSO for disposal and labeled with "Caution-Radioactive Material" sign. A log of all material flushed to sanitary sewer must be kept at sink and submitted to RSO.

_____ **Decay-in-Storage:** Materials with half-lives of 90 days or less will be packaged in sealed plastic bags and submitted to the RSO for decay-in-storage. All free liquids will be absorbed onto vermiculite or clay absorbent before transport to reduce possibility of spills. Packages must be properly labeled with labels available from RSO.

_____ **Transfer for Burial:** Those materials with half-lives longer than 90 days will be collected by the RSO for transfer for burial. The procedures for packaging and collection are the same as for decay-in-storage.

Please detail any waste disposal procedures expected in this lab that differ from those noted above.

Describe the type of waste you expect to generate in your processes (i.e., solids for decay-in-storage, liquids for sink disposal, solids for transfer for burial, etc.)

7. **Survey and Safety Equipment: Describe the survey and safety equipment available to radioactive materials users in this laboratory.**

Equipment (Location)	Manufacturer/ model number/ serial number (if applicable)	Calibration date (if applicable)	Radiation detected (α, β, γ) (if applicable)	Purpose (survey, wipe test, sample analysis, etc.)
Fume Hood: ( )				
G-M Meter: ( )				
LSC: ( )				

8. **Training and Experience with Radioactive Materials: Describe the formal or on the job training received by each person on this application.**

Name	Position (faculty, staff, student)	Formal Training (location, duration)	On the Job Training (location, duration)	Reed Training Date (Policy & Procedures review; test)	Experience (isotopes, radiation levels, location of past experience

9. Radiation Protection Program Summary

Initial the items to acknowledge that these practices are done in your laboratory.

_____	a.	Wear dosimeters and obtain assays as required
_____	b.	No eating or drinking in radionuclide use areas.
_____	c.	No food stored in radionuclide use areas.
_____	d.	Wear appropriate protective clothing and change any item that becomes contaminated.
_____	e.	Perform monitoring and/or wipe tests as required in Procedure 4: ***User Surveys***.
_____	f.	Label all containers, use areas, and contaminated areas with radioactive warning signs, stickers, or tape.
_____	g.	Post required notices and radioactive materials labels and caution signs as required.
_____	h.	Keep logs on all receipt, use and disposal of radioactive materials as required in Procedure 5: *Waste Disposal* and Procedure 6: *Radioactive Materials Package Ordering and Receipt*.
_____	i.	Keep inventory of all radioactive material in laboratory.
_____	j.	Properly dispose of all radioactive samples at the conclusion of the experiment, or reauthorize if samples must be kept beyond the duration of this authorization.

Principal User Signature: _____ Date: _____

Approved by Radiation Safety Committee:

Chairperson Signature: _____ Date: _____

*Reviewed By Radiation Safety Committee:

Chairperson Signature: _____ Date: _____

*If after 3 years there is no change in applicant's use of radioactive materials, the applicant may resubmit the original form for review and approval by the RSC.

APPENDIX A: EMERGENCY NOTIFICATIONS AND DOSE LIMITS

Agency	**State of Oregon Radiation Protection Services (OAR 333-120-0710)**		**Oregon Occupational Safety and Health Administration (OR-OSHA) (29 CFR 1910.1096 (l))**	
Emergency Information	Notification must be made by telephone and by telegram, electronic mail, or facsimile. **971-673-0490, 24 hours a day**		Notification must be made by telephone and by telegram **(503) 378-3272 or (800) 922-2689**	
Report Time Limits	Report **immediately** an event causing or threatening to cause:	Report **within 24 hours** an event causing or threatening to cause:	Report **immediately** an event causing or threatening to cause:	Report **within 24 hours** an event causing or threatening to cause:
Individual Dose	TEDE of 25 rem (0.25 Sv) or more	TEDE exceeding 5 rem (0.05 Sv)	≥ 25 rem (0.25 Sv) to whole body	≥ 5 rem (0.05 Sv) to whole body
	Lens dose equivalent of 75 rem (0.75 Sv) or more	Lens dose equivalent exceeding 15 rem (0.15 Sv)	N/A	N/A
	Shallow dose equivalent to the skin or extremities of 250 rad (2.5 gray) or more	Shallow-dose equivalent to the skin or extremities exceeding 15 rem (0.15 Sv)	≥ 150 rem (1.5 Sv) to skin ≥ 375 rem (3.75 Sv) to feet, hands, ankles, forearms	≥ 30 rem (0.3 Sv) to skin ≥ 75 rem (0.75 Sv) to feet, hands, ankles, forearms
Release of Radioactive Materials	Such that an individual present for 24 hours could receive an intake of 5x occupational annual limit	Such that an individual present for 24 hours could receive an intake greater than 1x occupational annual limit	Such that if averaged over 24 hours would exceed 5000 times the limits in 10CFR20 Appendix B Table 2	N/A
Other Types of Emergencies			The **death** of any employee or a catastrophe (**three or more employees admitted to a hospital**) within **eight hours of the incident or *within eight hours* after it has been reported to you**. *Report a fatality only if it occurs within 30 days of the incident.*[1]	An overnight hospitalization[2]

[1] ***Do not disturb the scene of a fatality or catastrophe*** until Oregon OSHA investigates the incident, unless a law

[2] Only report overnight hospitalization for medical treatment; do not report hospitalization for observation or for treatment in an emergency room.

Allowable Emergency Doses for Emergency Responders	**From EPA Manual of Protective Action Guides and Protective Actions for Nuclear Incidents (EPA 400-R-92-001, May 1992)**	
	Non life-saving, no specific authorization	Up to 5 rem (0.05 Sv); Take all reasonable achievable actions to minimize dose.
	Non life-saving, for protecting valuable property, by preventing the spread of radiation (e.g., fighting fires, diking contaminated water)	Up to 10 rem (0.1 Sv); Exceeding 5 rem unavoidable and all appropriate actions taken to reduce dose. Monitoring available to project or measure dose.
	Life-saving rescue or protecting large populations	Up to 25 rem (0.25 Sv); Exceeding 5 rem unavoidable and all appropriate actions taken to reduce dose. Monitoring available to project or measure dose.
	Life-saving rescue or protecting large populations	Greater than 25 rem (0.25 Sv) -- **by informed volunteers ONLY, who are fully aware of the risks involved.**

Radiation Dose Rates		
	Less than 2 mrem /hr (20 μSv /hr)	**Very low level** -- acceptable for the public for intermittent and/or short exposure.
	Between 2 mrem (20 μSv)/hr and 50 mrem (500 μSv) /hr	**Low to medium level**—acceptable for emergency life-saving and first aid. Keep public out.
	Above 50 mrem (500 μSv) /hr	**Higher level**—pay careful attention to stay time if life-saving and first aid is necessary

Response Levels for Emergency Protective Action Guides (PAG)	Nuclide	^{131}I		^{134}Cs		^{137}Cs		^{90}Sr		^{89}Sr	
	Infant or Adult	I	A	I	A	I	A	I	A	I	A
	Initial Activity Area Deposition (μCi [kBq] /m^2)	1.3 [48]	18 [660]	20 [740]	40 [1480]	30 [1110]	50 [1850]	5 [185]	20 [740]	80 [2960]	1600 [592,000]
	Forage Concentration (μCi [kBq] /kg)	0.5 [18.5]	7 [260]	8 [300]	17 [630]	13 [480]	19 [700]	1.8 [67]	8 [300]	30 [1110]	700 [25,900]
	Peak Milk Activity (μCi [kBq] /L)	0.15 [5.55]	2 [74]	1.5 [56]	3 [111]	2.4 [89]	4 [148]	0.09 [3.3]	0.4 [15]	1.4 [52]	30 [1110]
	Total Intake (μCi [kBq])	0.9 [33]	10 [370]	40 [1480]	70 [2590]	70 [2590]	80 [2960]	2 [74]	7 [260]	26 [260]	400 [15]

Response Levels for Preventative Protective Action Guides (PAG)		^{131}I	^{134}Cs	^{137}Cs	^{90}Sr	^{89}Sr
	Initial Activity Area Deposition (μCi [kBq] /m^2)	0.13 [4.8]	2 [74]	3 [111]	0.5 [19]	8 [296]
	Forage Concentration (μCi [kBq] /kg)	0.05 [1.9]	0.8 [30]	1.3 [48]	0.18 [6.7]	3 [111]
	Peak Milk Activity (μCi [kBq] /L)	0.015 [0.05]	0.15 [5.55]	0.24 [8.9]	0.009 [0.3]	0.14 [5.2]
	Total Intake (μCi [kBq])	0.09 [3.3]	4 [150]	7 [260]	0.2 [7.4]	2.6 [96.2]

APPENDIX B: OCCUPATIONAL AND PUBLIC RADIATION DOSE LIMITS [a] [b]

	State of Oregon Radiation Protection Services (OAR 333-120-0100)	Oregon OSHA [c] (29 CFR 1910.1096)	American Conference of Governmental Industrial Hygienists (ACGIH)	Departme nt of Energy (DOE)	Nuclear Regulatory Commission [d] (NRC)	International Atomic Energy Commission (IAEA)	International Commission on Radiological Protection (ICRP) (2010)
Occupational							
Whole body (deterministic) [e]	5,000 mrem per year	1,250 mrem per quarter for the whole body (head and trunk; active blood-forming organs or gonads)	2,000 mrem per year average over 5 years (10,000 mrem in 5 years), not to exceed 5,000 mrem in any single year	5,000 mrem per year	5,000 mrem per year	2,000 mrem per year average over 5 years (10,000 mrem in 5 years), not to exceed 5,000 mrem in any single year	2,000 mrem per year average over 5 years (10,000 mrem in 5 years), not to exceed 5,000 mrem in any single year
Lens of eye	15,000 mrem per year	1,250 mrem per quarter	15,000 mrem per year	15,000 mrem per year	15,000 mrem per year	15,000 mrem per year	5,000 mrem per year
Hands, forearms; feet and ankles	50,000 mrem per year	18,750 mrem per quarter	50,000 mrem per year	50,000 mrem per year	50,000 mrem per year	50,000 mrem per year	50,000 mrem per year
Skin	50,000 mrem per year	7,500 mrem per quarter	50,000 mrem per year	50,000 mrem per year	50,000 mrem per year	50,000 mrem per year	50,000 mrem per year
Embryo-fetus of pregnant worker [f]	500 mrem per gestation period	No limit established	50 mrem per month over gestation period	500 mrem per gestation period	500 mrem per gestation period	No limit established	100 mrem per gestation period
Cumulative	No limit established	5,000 (N-18) mrem N=age (y)	1000 mrem x age in years (y)	No limit established	No limit established	No limit established	No limit established

[a] Table based, in part, on NIOSH Health Hazard Evaluation Report 2003-0206-3067

[b] The dose limits are reported in the conventional units (mrem) to be consistent with the U.S. regulations.

[c] OSHA occupational dose limits are reported in terms of dose equivalent per calendar quarter and apply only to individuals who work in a restricted area. Restricted area means any area that is controlled by the employer for purposes of protecting individuals from exposure to radiation or radioactive materials. Minors are restricted to 10% of the limits shown.

[d] NRC states that if members of the public are continuously present in an unrestricted area, the dose from external sources cannot exceed 0.002 rem in an hour and 0.05 rem in a year.

[e] Occupational and public deterministic dose limits (except OSHA) are reported in terms of annual effective dose (E); the cumulative dose limit is a cumulative effective dose limit. The effective dose (E=wRHT) is intended to provide a means for handling non-uniform irradiation situations. The tissue-weighting factor (wR) takes into account the relative detriment to each organ and tissue including the different mortality and morbidity risks from cancer. In other words, the risks for all stochastic effects will be the same whether the whole body is irradiated uniformly or not.

[f] Embryo-fetus dose limit is an equivalent dose (Hg. T) limit in a month once pregnancy is known. The equivalent dose limit is based on an average absorbed dose in the tissue or organ (DT) and weighted by the radiation weighting factor (wR) for radiation impinging on the body (HT=wR DT).

	State of Oregon Radiation Protection Services (OAR 333-120-0100)	Oregon OSHA [c] (29 CFR 1910.1096)	American Conference of Governmental Industrial Hygienists (ACGIH)	Departme nt of Energy (DOE)	Nuclear Regulatory Commission [d] (NRC)	International Atomic Energy Commission (IAEA)	International Commission on Radiological Protection (ICRP) (2010)
Public							
Whole body (deterministic)	100 mrem per year	No limit established	100 mrem per year	100 mrem per year for members of the public entering a controlled area	100 mrem per year from licensed operation; *or* 2 mrem per hour from any unrestricted area	100 mrem per year (up to 500 mrem in a year in special circumstances if the average over 5 years does not exceed 100 mrem per year)	100 mrem per year (higher in special circumstances if the average over 5 years does not exceed 100 mrem per year)
Lens of eye, skin, and extremities [g]	No limit established	No limit established	No limit established	No limit established	No limit established	1,500 mrem to lens of eye *and* 5000 mrem to the skin per year	1,500 mrem to lens of eye *and* 5,000 mrem to skin, hands, and feet per year

[g] Lens of eye, skin, and extremity dose limit is an annual equivalent dose limit.

APPENDIX C: SEALED SOURCES TO BE LEAK TESTED

Reed ID Number	Isotope	Physical Form or ID numbers	Radiation Emitted	Activity	Location	Frequency of Tests
86-40	Americium-241	NEN #NER497 (or A-302)	α	30 mCi	C119 Storage	IN STORAGE
86-39	Plutonium-238	Kevex #3227 (or 0132	α	30 mCi	C119 Storage	IN STORAGE
96-03	Cesium-137	NER-401H capsule #G316B Cs-204	γ	10 mCi	C119 Storage	IN STORAGE
96-04	Cesium-137	NER-401H capsule #G316B Cs-810	γ	100 mCi	C119 Storage	IN STORAGE
n/a	Cobalt-60	Sealed source	γ	0.47 Ci	Storage Pit	IN STORAGE
86-36	Radium-226	Sealed source	γ	2 mCi	C119 Storage	IN STORAGE
06-40	AmBe	Troxler Density Gauge	n	40 mCi	C119 Storage	IN STORAGE
06-26	Plutonium-239	8 Sealed sources	n	7.5 Ci	Reactor Cave	6 months
07-01	Cesium-137	Shepherd Source	γ	0.9 Ci	C119	6 months
06-03	Iridium-192	Ir source in pool	γ	30 Ci	Reactor Pool	6 months (tested via water tests)

APPENDIX D: SEWER DISPOSAL LIMITS

From 10 CFR Table 3 Appendix B 20.1001-20.2401

			10 CFR 20 App B Table 3 (μCi/ml/month)							
			H-3	C-14	Na-24	P-32	S-35	Co-60	Se-75	I-125
			1.00E-02	3.00E-04	5.00E-04	9.00E-05	1.00E-03	3.00E-05	7.00E-05	2.00E-05
			1.00E-02	3.00E-04	5.00E-04	9.00E-05	1.00E-03	3.00E-05	7.00E-05	2.00E-05
	Minimum Water Volume (ft^3/month)		**Reed Sink Limits Based on Water Usage (milliCi/month)**							
			H-3	C-14	Na-24	P-32	S-35	Co-60	Se-75	I-125
January 2010	76,000		21,561.20	646.84	1,078.06	194.05	2,152.08	64.68	150.93	43.04
July 2009	102,400		29,050.88	871.53	1,452.54	261.46	2,899.64	87.15	203.36	57.99

Notes: The water usage data are from January and July because these are the two lowest water-usage months. Both months are provided to give a range for the disposal limit. The volume is much higher when classes are in session.
The table shows the nuclides that experimenters use and the three nuclides that show up most often at the reactor.
The sewer disposal limits from 10 CFR 20 Appendix B, Table 2 indicate the monthly average disposed to sewers.
Calculation: (water usage per month)(the limit)(convert μCi to mCi) = the number of millicuries Reed College personnel could dispose of each month for each nuclide.
Even with all the conservatism, this is more H-3 or C-14 than experimenters are likely to have on hand, much less dispose of down the sink.
The reactor would not dispose of mCi worth of any nuclide down the sink. They only wash off some contamination, which would be less than a microcurie.

APPENDIX E: HALF-LIVES OF SOME COMMON RADIOISOTOPES

Isotope	Decay mode	Half-Life	Common Locations / Uses	Decay Products (Half-Life)
Tritium (H-3)	β-	12.32 years	Exit Signs	Helium-3 (stable)
Carbon-14	β-	5700 years	Research labs	Nitrogen-14 (stable)
Sodium-24	β-	14.997 hours	Blood after neutron exposure	Magnesium-24 (stable)
Phosphorus-32	β-	14.262 days	Medicine, Biochemistry	Sulfur-32 (stable)
Sulfur-35	β-	87.37 days	Medicine, Tracer	Chlorine-35 (stable)
Cobalt-60	β-	1925.28 days	Medicine, Tracer, Sources	Nickel-60 (stable)
Selenium-75	Electron capture	119.79 days	Gamma Radiography	Arsenic-75 (stable)
Iodine-125	Electron capture	59.407 days	Medicine, Bio-assays	Tellurium-125 (stable)
Cesium-137	β-, γ	30.17 years	Fission product, Sources	Barium-137m (2.6 minutes)
Thorium-232	α	1.405×10^{10} years	Lantern mantles	Radon-228 (65 seconds)
Americium-241	α	432.6 years	Smoke detectors	Neptunium-237 (2,144,000 years)
Uranium-235	α	7.038×10^{8} years	Reactor fuel	Thorium-231 (25.5 hours)
Plutonium-239	α	24,100 years	Reactor fuel	Uranium-235 (7.038×10^{8} years)

See Procedure 1: Safe Use of Radioactive Materials for specific precautions when using some of the listed radioisotopes.

APPENDIX F: RECORD RETENTION

Retention times given below are the most conservative values of OAR, American Nuclear Insurers, and NRC requirements.

Required Record	Retention Time	Form/Document Used
Provisions of Radiation Protection Program	Until license termination[10]	Licenses for radioactive materials and x-ray equipment; Radioactive Materials Policy and Procedures Manual; Annual Report, X-ray license
Semi-Annual Inventory	5 years or until inspection by Oregon Radiation Protection Services[11], whichever is longer	Form 1: Semi-Annual Inventory Log
Results of Surveys	Lifetime of facility plus 10 years[12]	Form 2: Radiation Survey Report; Health Physics Log
Receipt/ Disposal of RAM	While material is possessed, and then 5 years following transfer or disposal.[13]	Form 3: Receipt, Use, and Disposal
Waste Disposal (on-site)	Lifetime of facility plus 10 years[12]	Form 3: Receipt, Use, and Disposal; Form 4: Sink Disposal Log; Form 5: Decay-in-Storage Log
Waste Disposal (off-site)	Indefinitely[14]	Manifests; Site registration; Site use permit
Contamination Occurrences	Lifetime of facility plus 10 years[12]	Form 6A: Contamination Log Form 6B: Contamination Report
Radiation Safety Committee Minutes	Lifetime of facility plus 10 years[12]	Committee minutes
Personnel Information	Duration of employment plus 30 years, or until license termination plus 10 years, whichever is longer[15]	Form 7: Personnel Training; Form 8: Application for Use of Radioactive Materials Program; Quarterly dosimetry reports; Reports to individuals; Bio-assay reports

[10] OAR 333-120-0610

[11] OAR 333-102-0910

[12] American Nuclear Insurers, "Nuclear Liability Insurance Records Retention"

[13] OAR 333-100-0057

[14] Until license termination per OAR 333-120-0670; indefinitely is Reed's requirement

[15] Oregon OSHA rules Division 2, Subdivision Z, 1910.1020

Required Record	Retention Time	Form/Document Used
Results of sealed source leak tests	Lifetime of facility plus 10 years[12]	Reactor SOP 51C
Results of calibrations	Until license termination[16]	Reactor SOPs 40, 41, 42, 43, 44, 46
Measurements used to determine individual dose or effluent release to the environment.	Lifetime of facility plus 10 years[12]	Reactor SOP 52; Reactor log for megawatt hours and related Argon release

[16] 5 years per OAR 333-120-0620; until license termination is Reed's requirement

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