



Radiation Safety Guide

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Introduction

This Radiation Safety Guide, approved by the University of Rhode Island Radiation Safety Committee, represents official university policy on radiation and radioactive material. As part of the broad-scope radioactive material license for the University of Rhode Island, violations of its policies and procedures are citable as areas of non-compliance by the Rhode Island Department of Health.

Our general policy is to hold the radiation dose received by any person from external and internal exposure to ionizing radiation at the University of Rhode Island to the lowest possible value consistent with effective use of radioactive materials and radiation producing machines. Exposure of personnel and the general public must never exceed legal limits.

Our radiation protection program is based on a dose limitation system consistent with three fundamental principles.

1. *Justification* – There should not be any occupational exposure without the expectation of an overall benefit from the activity causing the exposure.
2. *Optimization* – A sustained effort should be made to ensure that collective doses, as well as annual, committed and cumulative lifetime individual doses, are maintained as low as reasonably achievable (ALARA), economic and social factors being taken into account.
3. *Limitation* – Radiation doses received as a result of occupational exposure should not exceed the specified limiting values contained in the Rhode Island Department of Health (RIDOH) *Rules and Regulations for the Control of Radiation*.

Every effort should be made to avoid contamination of work areas and release of airborne or waterborne radioactivity exceeding legal limits. Every effort should be made to avoid accidental releases. Disposal of all radioactive waste shall follow procedures contained in this guide.

The radiation dose received by any person from external and/or internal exposure to ionizing radiation in a non-controlled area should be held as close to natural background levels as possible. Exposure to the general public from any operation at the University must not exceed the annual legal maximum dose equivalent level of 100 mrem (1 mSv) above the natural background level.

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

Our policy is to maintain occupational exposures of individuals within allowable Radiation Exposure Guides. Individual and collective dose to workers are maintained As Low As Reasonably Achievable (ALARA).

ALARA is a part of the normal work process where people are working with ionizing radiation. Management at all levels, and in all areas, as well as each individual worker, must take an active role in minimizing this radiation exposure. In accordance with our commitment to keep occupational exposure as low as is reasonably achievable, our ALARA program operates within the following objectives:

1. The annual total effective dose equivalent to individual workers shall be maintained ALARA with maximum annual whole body radiation exposure to any individual not to exceed 500 mrem (5 mSv).¹
2. Any radiation exposure during one monitoring period, (currently one calendar month), in excess of 100 mrem (1 mSv) is brought to the attention of the University's Radiation Safety Officer (RSO). The RSO investigates the exposure to determine why the exposure occurred, and take steps to prevent its recurrence. The Incident is brought to the attention of the Radiation Safety Committee and becomes an agenda item at its next scheduled meeting.

Failure to comply with the rules and regulations set forth throughout this guide may lead to disciplinary actions and/or the cessation of radioisotope shipments and experiments. The Radiation Safety Officer and/or the Radiation Safety Committee may suspend and/or terminate any radioisotope or radiation-producing equipment use authorization if continued authorization may result in situations jeopardizing health and safety, the environment or the URI broad license.

This guide discusses each topic by first presenting the governing university policy and regulatory requirements then outlining procedures by which you may meet those requirements. The Radiation safety Office will assist you in meeting those requirements and should be consulted if you have questions

¹ 500 mrem is 10% of the annual occupational limit set by our regulatory authority.

Responsibilities of the Authorized User

Policy

Authorized Users are directly responsible for compliance with all regulations governing radiation safety in the laboratory, and for safe practices of individuals working under their supervision.

Regulatory References

Broad Scope License

Procedure

Authorized Users must:

1. Ensure that individuals working under their control are properly supervised and trained to enable safe working habits and prevent exposures to themselves and others and/or contamination of the work areas or environment. Inadequate supervision and lack of training have been cited as indicative of negligence in lawsuits involving radiation.
2. Be aware of the potential radiation hazards inherent in a proposed activity; be responsible for instructing personnel in safe practices or directing personnel to sources of information concerning safe practices.
3. Maintain inventory and knowledge of the various forms (physical and chemical) and quantities of radiation that are present in their work areas.
4. Avoid any unnecessary exposure, either to themselves or to other workers.
5. Understand the risks associated with the possession, use and shipment of all radioactive materials. Federal and state regulations control the use and shipping of radioactive materials and certain other hazardous materials.
6. Keep current records of the receipt and the disposition of radioactive material in their possession including use in research, waste disposal, transfer, storage, etc.
7. Maintain constant surveillance and immediate control of radioactive materials to prevent unauthorized removal or tampering, and/or assure that all of the workers occupying the area maintain security.
8. Post warnings and restrict entry to areas that contain potentially hazardous radioactivity or chemicals. Label radioactive use equipment and work areas.
9. Notify the Radiation Safety Office of any personnel changes, including addition or termination of employees, or changes of areas where radioactive materials may be used or stored.
10. Assure instruction of female radiation workers of the risks associated with working with radioactive materials during pregnancy. (NRC Reg. Guide 8.13).

11. Assure designation of a responsible individual to oversee radioisotope work during short absences, and of a stand-in Authorized User with the required committee approvals during extended absences (greater than 60 days).
12. Ensure that radiation safety surveys and audits in the laboratory are conducted, and maintain records for review.
13. Be aware of regulations and requirements pertaining to the use of radioactive materials, maintain compliance and a safe working area.
14. Use radioactive materials according to statements, representations and conditions set forth in the radioactive materials use approval given by the Radiation Safety Committee².
15. Maintain use logs for radioisotopes.

² Note: Changes from the approved procedures must be approved by the Radiation Safety Committee in an amendment or new application prior to the implementation of the change.

Responsibilities of the Radiation Worker

Policy

Individuals who use radioactive materials assume certain responsibilities in their work. The individual radiation worker is the "first line of defense" in protection of people and the environment against undue risks of radiation exposure and/or contamination. Since the radiation workers, themselves, are the direct handlers of the radioactive material, the final responsibility lies with them for safety and compliance with laws and regulations. For this reason, it is critical that they be aware of the risks, safe practices and requirements for use of radioactive materials.

The term "radiation worker," (as used in this Guide), is an individual who uses radioactive material and/or radiation-producing equipment in the course of his/her employment or study with the university. Radiation workers may be Authorized Users, graduate students, undergraduate students, technicians, post-doctorates, visitors, or any other individual who will handle radioactive material.

Regulatory References

Broad Scope License

Procedure

Radiation workers will:

1. Complete the Principles and Practices training class. Radiation workers are prohibited from using radiation-producing equipment or handling radioactive materials until this class has been completed. Radiation workers must attend a refresher session each year.
2. Complete the radiation safety examination and pass with a score of 70% or better.
3. Comply with to all laws, rules, regulations, license conditions and guidelines pertaining to the use of radioactive materials.
4. Wear their assigned radiation dosimeter³ during uses of radioactive materials.
5. Practice ALARA (As Low As Reasonably Achievable) in their work, and minimize the potential for exposures, contamination or release of radioactive materials.
6. Monitor radiation work areas after each use of radioactive material. If contamination is found, it must be cleaned up.

³ Dosimeters may not be assigned to certain workers using only low-energy beta emitters. Those workers are, obviously, excused from this requirement.

7. Make no changes in experimental procedures using radioactive materials without the approval of the Authorized User. Do not take short cuts. The Radiation Safety Committee must approve changes in experimental procedures impacting safety (higher quantities, higher risk, use in animals, etc.).
8. Report any abnormal occurrence immediately to the Authorized User, such as spills, significant contamination, equipment failure, loss of radiation dosimeters and unplanned release. If the Authorized User cannot be reached, contact the Radiation Safety Office.
9. Clean any contamination or spills that occur in their work area. DO NOT LEAVE IT FOR ANOTHER PERSON TO CLEAN UP.
10. Return the radiation dosimeter on time and report any loss or contamination of the dosimeter to the Radiation Safety Office.
11. Inform the Radiation Safety Office of any exposures that have occurred at a previous employer when beginning employment at URI. They are also responsible for notifying the Radiation Safety Office of termination of employment and returning the radiation dosimeter at the end of their employment.
12. Maintain security of radioactive materials.

Authorized User and Worker Training

Policy

The Radiation Safety Office provides radiation safety training for individuals who work with or around radioactive materials or other generators of ionizing radiation. Authorized Users and workers using radioactive materials must have initial training before using radioactive materials. Annual retraining is required for the continued use of and authorization to possess radioactive materials. Non-radiation workers (Maintenance, Shipping and Receiving, Custodial, and Security) are retrained annually. Ancillary training is tailored to specific job functions .

Regulatory References

RIDOH § A.6.3
10 CFR 19.12

Procedure

All new radiation workers should review the Radiation Safety Guide, the Training Manual for Users of Radioactive Material, and the Authorized User's radioactive materials use protocols before attending the new user training class. Copies of the Radiation Safety Guide and Training Manual are available at the Radiation Safety Office.

Each Authorized User is responsible for training workers under his/her supervision on radiation safety procedures and practices specific to each particular laboratory.

Call the Radiation Safety Office at 789-9391 to sign up for a new training or a retraining class.

Special classes for large groups may be given as needed if prior arrangements are made.

Non-radiation workers (i.e., Maintenance, Shipping and Receiving, Custodial, and Security) are retrained annually by the Radiation Safety Office and are scheduled through the individual departments. Additional training classes for administrative and secretarial staff are also offered.

Pregnant Radiation Workers

Policy

A special situation arises when a radiation worker becomes pregnant. Under these conditions, radiation exposure could also involve exposure to the embryo or fetus. A number of studies have indicated that the embryo or fetus is more sensitive than the adult, particularly during the first four months of pregnancy. This can be a problem since many workers are unaware of their pregnancy during the first month or two of gestation. Hence, the State of Rhode Island requires that all occupationally exposed workers be instructed concerning the potential health protection problems associated with prenatal radiation exposure. This instruction is completed during radiation worker training.

The State of Rhode Island also requires that the maximum permissible exposure for a declared pregnant worker during the gestation period is 500 mrem. There are relatively few research laboratories where radiation levels are high enough that a fetus would receive this dose before birth.

Regulatory References

RIDOH §A.2.10 and A.5.7

Procedures

If a radiation worker is pregnant, she may notify the Radiation Safety Officer, and then declare the pregnancy in writing in order for the prenatal exposure limits to take effect. The pregnant radiation worker will then meet with the Radiation Safety Officer, and a complete assessment of her radiation exposure potential will be made. She makes the written declaration by completing a Declaration of Pregnancy form. The Radiation Safety Office maintains the form in its records.

Declared pregnant workers (DPW) will be assigned two badges, one for the whole body, normally worn on the torso and one for the fetus, normally worn on the abdomen. The badges will be exchanged on a monthly basis. Exposures should be maintained beneath a cap of 50 mrem per month in order to prevent exposure spikes. An individual may "un-declare" her pregnancy at any time, but this also should be documented.

Application for Use of Radioactivity and/or Radiation Sources

Policy

The Radiation Safety Committee authorizes specific individuals to acquire and use radioactivity and/or radiation sources. Normally, those individuals are members of the faculty or staff. Persons not specifically authorized, (e.g., graduate students, post-docs, technicians, and visitors), may use sources of radiation only under the supervision of the faculty or staff members so authorized. Those seeking authorization must be familiar with the requirements of this guide.

Regulatory References

Broad Scope License

Procedure

Applicants submit Form C/R NUC-1 in triplicate to the Radiation Safety Office for authorization to use radioactive material. Applicants who wish to operate x-ray machines, electron microscopes, accelerators or any device operating at sufficient voltage to produce ionizing radiation should contact the Radiation Safety Office. The application procedure varies according to the type of device being requested. Form NUC-2 may be used.

Note: Lasers should also be registered with the Radiation Safety Office using form NUC-2L (available at the Radiation Safety Office).

For radioactive materials use, the applicant must provide a description of the radioactive material, its proposed use, the applicant's qualifications, available radiation detection instruments, available laboratory facilities, a basic radiation protection program for the laboratory, and waste disposal techniques.

If the Radiation Safety Committee determines that the training, facilities and safety precautions are adequate for the radiation sources requested, a formal written authorization to use the source of radiation will be issued. The authorized user must keep a copy of authorization on file.

Authorization must be received before an individual purchases or receives radioactive materials.

After tentative Committee approval of an application for a radiation-producing machine, the applicant may procure the device. The Radiation Safety Office will do a radiation survey when the device is operable and the state registration certificate has been received.

Acquisition of Radioactive Materials

Policy

Radioactive material may be acquired only by an Authorized User (AU) or individuals specifically listed in the Authorized User's isotope application. Form C/R NUC-1 should designate individual(s) approved to sign requisitions for isotope purchases. The Radiation Safety Office must approve all radioactive material purchases before the order is processed through the Purchasing Department.

The Authorized User must be approved to possess the isotope and activity ordered. The activity, when added to the current isotope inventory, may not exceed the Authorized User's approved possession limit for that isotope.

Any acquisitions of radioactive materials from a vendor, collaborator or another institution require prior approval of the Radiation Safety Office. This policy includes replacement shipments, trial kits, and free samples.

Regulatory References

10 CFR 30.33
Broad Scope License

Procedure

Requests for acquisition of radioactive material require approval by the Radiation Safety Office. Figure 1, (on the next page), provides an overview of the three general ways radioactive materials may be acquired at the University. In each instance, the Radiation Safety Office will review each request to ensure that the isotope, activity and chemical form are consistent with the user's authorization. If those conditions are met, the Radiation Safety Office will approve the acquisition.

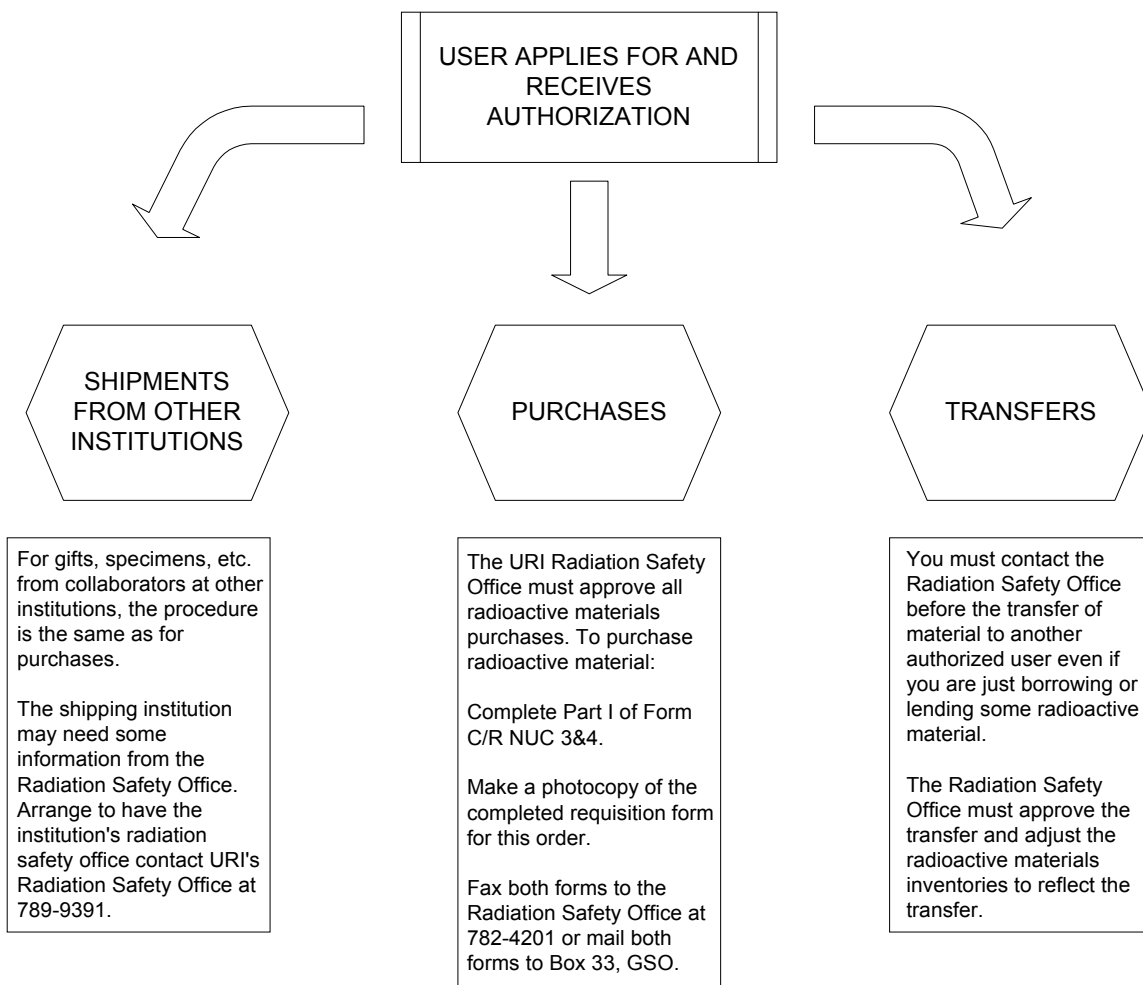


FIGURE 1: OBTAINING RADIOACTIVE MATERIALS AT THE UNIVERSITY OF RHODE ISLAND

When filling out a purchase requisition, the following information is required for processing by the Radiation Safety Office and must be clearly printed on the requisition:

1. The name of the Authorized User. All information maintained by the Radiation Safety Office about each laboratory is keyed through each Authorized User, so the name URI must be present.
2. An authorized signature. Only the Authorized User's or a designee's signature will be accepted.
3. Location and phone number of the laboratory that is approved for RAM use.
4. The isotope (H-3, C-14, P-32, S-35, I-125, etc.), activity, and chemical form desired.
5. Express activity in units of millicuries (mCi) or microcuries (μ Ci). Orders without isotope identification, activity, and chemical form will not be approved.

6. The vendor and catalog number for the isotope ordered.

Fax or deliver your purchase order to the Radiation Safety Office. The Radiation Safety Office tries to approve each order for radioactive material on the same day it is received.

For shipments from other institutions, follow the same procedures used to purchase radioisotopes. For transfers of radioactive materials within the University, follow the procedures in the Internal Transfer subsection of the section on the Transfer of Radioactive Materials within this Guide.

Deliveries are sent to the authorized user's laboratory. After delivery, the laboratory's isotope inventory log must be updated for all radioactive material in the laboratory.

If the received activity differs by more than 20 % on the Radioactive Material Package Receipt form from the ordered activity, please call the Radiation Safety Office and provide the corrected activity and the corresponding assay date.

Inform the Radiation Safety Office of canceled orders for radioactive materials. Otherwise the activity may be assigned automatically to your inventory by our computer.

Radioactive shipments ordered during an Authorized User's absence will be tracked under the absent Authorized User's inventory.

Receipt of Radioactive Material

Policy

The Authorized User or designee shall survey all radioactive material packages and contents upon receipt for contamination levels and evidence of damage or breakage.

Regulatory References

RIDOH § A.3.17
10 CFR 20.1906
10 CFR 71.47

Procedure

Inspect every package containing radioactive material for leakage and dose rates. If the dose rate is greater than 10 mR/hr at 1 meter, or greater than 200 mR/hr at the surface (10 CFR 71.47), do not open the package and notify the Radiation Safety Office immediately.

Packages of radioactive materials should be opened using the following procedures approved by the Radiation Safety Office:

1. Wear proper protective clothing (a buttoned lab coat; latex, vinyl, butyl, or nitrile gloves; and a body and ring badge as needed).
2. Check for evidence of potential contamination, (packages that are crushed, wet, or damaged).
3. Open all packages containing volatile radioactive materials (S-35 and Iodines) in an approved fume hood.
4. Monitor all packaging material for contamination with a hand-held survey meter appropriate for the isotope received.
5. Conduct wipe tests on the outside of the container and the packaging material contained in the shipment for removable contamination.
6. Determine the activity of the wipes with an appropriate counting device. Record the activity in units of dpm/100cm² or $\mu\text{Ci} / 100\text{cm}^2$.
7. If there is any evidence of leakage or external contamination, contact the Radiation Safety Office immediately.

8. If there is no isotope contamination, remove and/or completely deface the trefoil warning labels before disposing of the items as non-radioactive trash.
9. Retain all survey results for the shipment for a minimum of three years.

Transfer of Radioactive Materials

Policy

The Radiation Safety Office reviews all procedures for transfer of radioactive material to or from an Authorized User, either on campus (internal transfer) or off campus (external transfer). Radioactive materials may not be transferred to another investigator or location until this review process has been completed. Transport of radioactive materials between URI Authorized Users approved for the isotope transfer shall proceed in a manner that minimizes exposures and risks from accidental release of radioactive material. Transport of radioactive materials off-campus must conform to all applicable state and federal regulations. It is essential to obtain approval from the Radiation Safety Office before shipment.

Regulatory References

49 CFR 172 - 173
10 CFR 71
10 CFR 30 Schedule A
RIDOH § A Appendix C
10 CFR 20 Appendix C
Broad Scope License

Procedure

Internal Transfer

Before initiating an internal transfer of radioactive materials, verify that the Authorized User receiving the transferred material is authorized to possess the isotope. The sending and receiving Authorized Users, and the Radiation Safety Office must sign an Internal Transfer form before the transfer may proceed. A copy of the form, approved by the Radiation Safety Office, will be returned to both Authorized Users. The transfer may occur only after receipt of the approved transfer form. If the internal transfer will involve the use of a motor vehicle, a Bill of Lading must also be completed.

External Transfer

Before initiating an external transfer of radioactive materials, an External Transfer form must be completed and forwarded to the Radiation Safety Office. Information provided must include the isotope, activity and chemical form. A copy of the recipient institution's license must also be on file in the Radiation Safety Office. A contact phone number and fax number will help speed the Radiation Safety Office process for obtaining approval from the receiving institution for the shipment. The Radiation Safety Office will sign the form and return it with

appropriate instructions marked for packaging, labeling and shipment. Do not proceed with the transfer until this form is returned.

The following information provides general guidelines for packaging radioactive material. If additional information or clarification is needed, please contact the Radiation Safety Office (789-9391).

1. Obtain an appropriate container such as the type of package used to receive radioactive material shipments from vendors.
2. All DOT labeling requirements must be met.
3. For "Limited Quantity" material, mark the inner package "RADIOACTIVE," in an area that is readily visible when the package is opened.
4. Use suitable packing material to prevent shifting of the material in the package during handling and shipment. If the material is a liquid, use enough absorbent material to absorb all the liquid in case of breakage.
5. Close the package, ensuring that any seals are secure. If fiberboard boxes are used, use packing tape to seal the package.
6. Perform radiation and contamination surveys of the package. Radiation and contamination levels shall not exceed the following:
 - a. 2200 dpm/100 cm² (40 Bq/100 cm²) beta-gamma contamination;
 - b. 220 dpm/100 cm² (4 Bq/100 cm²) alpha contamination;
 - c. 0.5 mRem/hr (0.005 mSv/hr) at any point on the external surface.

Note: Although the above limits apply, no removable contamination should be permitted on package exteriors.

7. Mark the name and address of the consignee (recipient) on the top of the package. If the name and address of the consignee are not readily visible on the top of the package, they may be placed in a visible area on the side of the package.
8. Attach the packing list (straight bill of lading) to the package. The package is ready for shipment by an approved carrier. Allow at least two days for package delivery.

Security of Radioactive Materials

Policy

Radioactive materials shall be secured against unauthorized access or removal when unattended.

Regulatory References

10 CFR 20.1801,1802
RIDOH § A.3.10, A.3.11
Broad Scope License

Procedure

Each laboratory is responsible for securing and controlling access to isotope inventory when no authorized individual is in the area and constant surveillance cannot be maintained.

Equipment in hallways containing radioactive materials (cabinets, refrigerators, freezers) must be locked or contain a secured lock-box within.

If the equipment (cabinet, refrigerator, and/or freezer) is not being used for radioactive materials, the equipment shall be decommissioned.

For equipment that is used occasionally for radioactive material storage, the equipment shall be locked even if no radioactive materials are currently present.

Security checks by the Radiation Safety Office are conducted periodically after normal working hours to ensure that areas where radioactive materials are present are properly secured.

Unattended Operations

Policy

An experiment is considered to be unattended if there is no one present who is knowledgeable of the operation and of the shutdown procedure to be followed in the event of an emergency. Unattended operations involving radioactive materials or radiation-producing equipment shall meet the requirements in the procedures below.

Regulatory References

Broad Scope License

Procedure

Experiments that are left unattended must have overriding controls with automatic shutdown devices to prevent system failure that could result in fire or explosion, for example, the loss of cooling water, overheating, flooding, and pressure buildup. Permanent piping, and shields or barriers if necessary, should be provided.

Warning signs must be used if radiation, toxic fumes, or other hazardous conditions are present. Custodians, utility, or security personnel need to be warned of them.

The laboratory entrance door should display an Emergency Notification sign naming the people to contact in case of trouble.

All unattended electrical heating equipment must be provided with fail-safe oven temperature shutoff controls, as overheating can result in a fire hazard.

Burners, induction heaters, ovens, and furnaces must be located away from areas where temperature-sensitive and flammable materials are handled.

Fan-cooled heating equipment must be equipped with an interlock arranged to disconnect current to the heating elements when the fan is inoperative.

If your equipment is potentially dangerous and must be left on overnight, consult with the Radiation Safety Office to see whether it is permissible to do so. Ensure that persons who may have to check the room can re-enter exterior doors (check with campus security). Notify the building manager (as some repair work and janitorial services are often performed during the night hours).

Post a notice on your equipment describing possible malfunctions, emergency shutoff procedures, and the nature of the hazards.

Bunsen and other gas burners without approved flame-failure devices must not be left on overnight. Gas pressure often fluctuates; an increase in pressure will cause a taller, hotter flame, overheating equipment and perhaps causing a fire. If the pressure decreases the flame may go out. Upon resumption of gas flow unburned gas will accumulate to create a fire or explosion hazard.

Over-temperature cutoff devices should be used on heated oil baths.

Use permanent piping if you must supply water to an overnight experiment. A sudden rise in pressure due to water fluctuations may rupture plastic or rubber experimental apparatus and cause flooding of lower floors. Floor flooding also takes place when water is left running into sinks to maintain a desired level and the drain becomes blocked or plugged. Consideration should be given to the use of standing overflow devices, which make drain plugging less likely.

Electrical extension cords shall never be left plugged in while unattended (they are for temporary use while working with portable equipment in rooms where receptacles are not available).

Protect the cords of electrical devices that must operate unattended. Prevent chemical or physical damage to the cords, by draping cords away from foreseeable hazards and heat sources.

Radioactive Waste Disposal

Policy

The Authorized User shall implement an effective radioactive waste management program that includes proper labeling, shielding, minimization, and assurances that disposals go into the correct waste stream.

Regulatory References

10CFR 20.1101(a)

RIDOH § A.2.2

10CFR 20 Subpart K (waste disposal--general requirements)

RIDOH § A.4

10CFR 60.71 Subpart D (general record-keeping and reporting)

10CFR 61.55-56 (waste classification and labeling)

40CFR 261 (ID listing of hazardous waste under RCRA)

40CFR 302 (designation, reportable quantities and notification under CERCLA)

29 CFR 1910.1200 (Hazard Communication Standard)

Procedure

The Authorized User is responsible for obtaining all containers and shielding required for his/her waste management program, as well as for maintaining written inventory records of the activity of all contaminated wastes in storage and those removed from the laboratory.

Radioactive waste should be separated by type--dry solids, gels, vials, sharps, animals, and liquids--and by isotope. Dual-label experiments are the only exceptions to this policy.

DO NOT place radioactive waste in the hallways where housekeeping personnel might pick it up.

Liquid radioactive waste should be double contained so that leakage from a breach in the primary container is fully contained by the secondary vessel.

Contaminated waste containing biohazardous materials must be sterilized before being transferred to the Radiation Safety Office for disposal.

Sewer disposal

No liquid radioactive waste may be disposed into the sanitary sewer system unless it meets all federal, state, local, and university regulations governing disposal of chemicals to the sanitary sewer system. Each Authorized User is responsible for discharges from his/her laboratory.

Any liquid disposed into laboratory sinks enters the sanitary sewer system and must meet Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) requirements for disposal to groundwater. Therefore it must be water-soluble or readily dispersible in water, its pH must be between 6 and 8, and it cannot contain any regulated chemicals. Contact the Radiation Safety Office with any questions about regulated chemicals in buffer solutions.

The Authorized User is responsible for maintaining a record of all quantities of radioactive liquids disposed into the sewer system. The isotope, activity, chemical form, and date of disposal must be specified on the sewer disposal form, which should be posted at or near the sink where the waste is being disposed. The Radiation Safety Committee must approve any change in the disposal protocol.

Disposal through the Radiation Safety Office

Liquid waste not disposed of via laboratory drains may be transferred to the Radiation Safety Office for disposal. For each bottle of liquid waste, a separate Disposal Listing for Liquid Radioactive Waste Form must be filled out. This form provides information regarding the isotope, activity, date, chemical constituents, pH, and chemical form. Liquid waste must have a pH between 6 and 8. This applies to all liquids whether or not they contain regulated chemicals. The laboratory must neutralize liquid waste prior to the waste being picked up for disposal. Survey the outside of the liquid waste container to make sure it is not contaminated and that the container's lid has been tightened.

Liquid waste should be placed in recyclable containers that can be returned to the laboratory by the Radiation Safety Office. These containers should be made of heavy gauge plastic with not more than a four-liter capacity. Judgment should be used in the selection of plastics since many organic chemicals will dissolve them. Some plastics are relatively inert and have good chemical resistance to toluene, phenyls, esters, ketones, and alcohols. These plastics include unmodified polypropylene, polytetrafluoroethylene (Teflon), and polytrifluorochloroethylene.

The Radiation Safety Office will not accept liquid waste that has been placed in glass containers. Contact the Radiation Safety Office if you have any questions about the type of container to use for your liquid waste or if your liquid waste contains any regulated chemicals.

Collection and Disposal of Animal Remains and Biohazardous Waste

Radioactive animal waste includes cage bedding, carcasses, viscera, excrement, serum, blood or other animal tissue containing radioactive materials. Radioactive animal waste should be kept in a -20 ° C freezer. These wastes should be

bagged and labeled in the same manner as dry solid waste. All waste placed in the freezer should be logged onto an animal disposal sheet kept on the cold room door. A log sheet for animals should also be kept in the lab for inventory purposes.

DO NOT mix animal remains and wastes with any of the solid or liquid radioactive storage containers in the lab, and do not place radioactive animal remains and wastes in dumpsters, cold rooms, or any other facility.

Any item that has come in contact with any etiologic agent is considered biohazardous and should be placed in a red biohazardous container. Etiologic agents include bacteria, fungi, viruses and parasites. This infected animal waste should be autoclaved (unless the radioactive isotope is volatile) and placed in the appropriate waste stream for disposal by the Radiation Safety Office.

Collection and Disposal of Lead Pigs

The inner lead lining of a lead pig must first be removed from the plastic container. The plastic container should then be surveyed to make sure it is uncontaminated. Any radiation label must be completely defaced before the plastic container is disposed of as regular trash. Lead is a regulated material and cannot be disposed of as trash. It must also be surveyed and free of contamination before the Radiation Safety Office will pick it up.

Personal Protective Equipment

Policy

The use of Personal Protective Equipment (PPE) is required when working with radioactive materials.

Regulatory References

10 CFR 20.1101
RIDOH § A.2.2
Broad Scope License

Procedure

Laboratory coats, gloves, and safety glasses are the primary form of protection against contamination. In general, PPE is meant to prevent direct skin contamination and minimize the risk of internal contamination. To minimize contamination:

1. Aprons, lab coats, gloves, or other protective clothing should be readily available and used.
2. Monitor hands, shoes, and clothing for contamination after each procedure and before leaving the area.
3. In case of spill, a change of clothing should be available.
4. Do not wear PPE (lab coats or gloves) outside the laboratory.

Eye Protection

Eye protection is required if there is risk of splash or splatter in the laboratory and where radioactive material is stored and handled. Contact lenses shall not be worn when working with volatile chemicals in the laboratory. Where there is a danger of splashing or flying particles, safety goggles are mandatory.

Laboratory Coats

Laboratory coats and other PPE shall be worn at all times while handling radioactive material. Laboratory coats should be fastened completely to provide more complete protection. Dresses, shorts, ties, or other dangling clothing should not be worn while conducting experiments in the laboratory. Protection for legs and feet should be provided by the laboratory coat and shoes. Open-toed shoes or sandals are not permitted. During a spill cleanup, Tyvek suits, sleeve protectors, and booties can be worn as protective covering.

OSHA regulations prohibit employees from taking laboratory coats home to be washed. Laboratory coats should not be washed at community laundromats. As an alternative, arrangements can be made with commercial laundering services to clean laboratory coats for a nominal cost.

Laboratory coats must be checked for radioactive contamination and decontaminated before they are taken to the laundry. If a laboratory coat cannot be decontaminated, it shall be brought to the Radiation Safety Office.

Gloves

Selection of proper glove materials is important. Disposable gloves should be worn while handling unsealed radioactive material. Contaminated gloves must not be reused and must be disposed of as radioactive waste. Potentially contaminated gloves should not be worn when handling non-contaminated materials.

Bioassays

Policy

Bioassays are required for radiation workers, who are likely to receive a measurable internal radiation dose. Bioassay procedures include, but are not limited to, thyroid screening and urinalysis.

Regulatory References

NRC Regulatory Guide 8.20, Applications of Bioassay for I-125 and I-131
NRC Regulatory Guide 8.32, Criteria for Establishing A Tritium Bioassay
10 CFR 20.1204
RIDOH § A.2.6
Broad Scope License

Procedure

The Radiation Safety Office currently performs routine bioassays for radioactive iodine (thyroid scan) and tritium uptake (urinalysis).

Radioactive iodine

A bioassay is required any time more than 1 mCi of radioactive iodine in volatile form is used.

The Radiation Safety Office must be notified before handling more than 1.0 mCi of volatile radioactive iodine to perform a baseline bioassay for anyone involved in the procedure who does not have a baseline radioactive iodine bioassay on file.

The Authorized User should contact the Radiation Safety Officer to arrange for the Radiation Safety Office to monitor effluent releases to the atmosphere during the iodination to measure or mitigate any release of radioactive iodine to the environment.

After the iodination, all individuals involved must contact the Radiation Safety Office and arrange for a bioassay to be completed the next business day.

Tritium

The Radiation Safety Office must be notified before handling more than 10 mCi of H-3. Tritium sources in metallic foils are exempt from bioassay requirements. If bioassays are to be performed, a baseline bioassay will be performed for anyone involved in the procedure who does not have a baseline H-3 bioassay on file.

Urine bioassays must be done for tritium users in accordance with the following schedule:

1. Less than 100 mCi: bioassays are performed at the discretion of the Radiation Safety Officer or when requested by the investigator or the Radiation Safety Committee.
2. Greater than 100 mCi but less than 1.0 Ci: bioassays are performed weekly until results are in the normal range.
3. Greater than 1.0 Ci: bioassays are performed daily until results are in the normal range.

Following approval by the Radiation Safety Officer, tritium users may perform their own bioassays and submit the results to the Radiation Safety Office. The bioassay procedure can be obtained from the Radiation Safety Office.

Personnel Monitoring

Policy

Each individual likely to receive a measurable radiation dose shall wear a personal radiation dosimeter. This includes all laboratory workers, visitors to the laboratory, or other workers working in the laboratory. Other personnel may request dosimetry that will be provided at the discretion of the Radiation Safety Office.

Regulatory References

10 CFR 20
RIDOH § A
10CFR 20 Appendix C
RIDOH § A Appendix B
Broad Scope License

Procedure

Obtaining Dosimetry

The Radiation Safety Office issues personal radiation dosimeters to new radiation workers and personnel who are likely to receive a measurable radiation dose. Radiation workers must complete the New Radiation Worker Training Class and fill out an Occupation Exposure History Form. If there is any doubt concerning the need for radiation dosimetry, contact the Radiation Safety Office.

Proper use of Dosimetry

The whole body dosimeter shall be worn between the neck and waist. If, however, one area of the body is more likely to be exposed than the rest, the dosimeter should be worn in that area. The front of the dosimeter must be exposed toward the source of radiation with no obstruction such that it correctly samples the actual exposure of the radiation worker. Dosimetry shall be worn outside of any personal protective equipment (e.g. apron or laboratory coat).

Extremity dosimeters (ring dosimeters) should be worn under any protective gloves on the hand most likely to receive the greatest exposure. The front of the ring dosimeter should face toward the radiation source.

Dosimeters are issued to a single user and shall not be shared. Dosimeters must to be returned promptly at the end of each cycle to assure the Radiation Safety Office can take timely action, consistent with implementation of ALARA, in the event any significant dose is measured.

Proper storage of dosimeters

Store dosimeter in a radiation-free area, such as a desk drawer, when not in use. Do not take the dosimeters home.

Lost/Damaged Badges

Report lost or damaged dosimeters (crushed, broken, melted, washed, accidentally-exposed, contaminated, heated in any way, etc.) to the Radiation Safety Office as soon as you are aware of the situation. Fill out a Lost Badge Form if a dosimeter cannot be found.

Pregnant Worker Program

Any radiation worker who is pregnant or thinks she may be pregnant may declare herself a Pregnant Worker by completing a Declaration of Pregnancy Form and sending it to the Radiation Safety Office. Counseling will be provided and an additional dosimeter will be issued which is read every month. This additional fetal dosimeter will be worn to measure any dose to the developing baby.

Neutron Users

For experiments and procedures involving the use of neutron sources, personnel monitors sensitive to neutron radiation should be worn. The Radiation Safety Office and/or the Radiation Safety Committee may require these monitors. They may be requested by the Authorized User and obtained from the Radiation Safety Office.

Analytical x-ray users

X-ray equipment used for x-ray diffraction or fluorescence analysis is known as analytical x-ray equipment. Analytical x-ray users should wear extremity dosimeters.

Healing arts x-ray users

X-ray equipment used for human or animal diagnostic or therapeutic work is considered healing arts x-ray. Healing arts x-ray users should wear whole body dosimeters.

Other sources and devices

The Radiation Safety Office will evaluate the need for personnel monitoring for other radiation sources and devices.

Laboratory/Contamination Surveys

Policy

Authorized Users shall perform contamination surveys and document the results in appropriate units for all areas where radioactive materials are used or stored under their supervision. The Radiation Safety Office will conduct periodic surveys and audits to assure proper use of all radioactive material.

Regulatory References

10 CFR 20.1501, 20.2101 & 20.2103
RIDOH § A.3.2, A.4.1, A.4.3
NRC Regulatory Guide 8.23
Broad Scope License

Procedure

Weekly surveys are required for all laboratories that use or otherwise handle stock concentrations of any isotope at any one time. Post-experiment surveys may be used instead of weekly surveys. Survey documentation shall include meter efficiencies and confirm that limits for removable contamination or restricted area exposure rates are not exceeded (see the Glossary of this guide for definitions of restricted areas). All records require both count rate measurements with an appropriate, calibrated survey meter and wipe tests performed to identify removable contamination. The following recommended action levels were adapted from NRC Regulatory Guide 8.23, Table 2.

Type of Surface	Alpha Emitters Dpm/100 cm ²	Beta or Gamma Emitters Dpm/100 cm ²	Low-Risk Beta or Gamma Emitters Dpm/100 cm ²
Unrestricted Areas	22	220	2,200
Restricted Areas	220	2,200	22,000
Personal Clothing worn outside restricted areas	22	220	2,200
Protective clothing worn only in restricted areas	220	2,200	22,000
Skin	220	220	2,200

For tritium-only users, wipe tests will be sufficient to meet survey requirements since tritium is not detectable with a survey meter. To perform a standard survey:

Gather all necessary items including: a map of the survey area for marking locations of probe readings and wipe test; an appropriate calibrated meter; material for performing the wipe test such as cotton swabs, tissue or filter papers; vials in which to place the wipes; and tweezers to allow handling of the wipes without cross-contaminating the samples.

Survey the laboratory thoroughly with the survey meter, concentrating on areas where radioactive materials have been used. Do not overlook areas where radiation users may have inadvertently walked or items that they may have touched. Hold the meter as close to the surface as possible without touching to avoid contaminating the meter. Move slowly and deliberately along lab benches, near selected floor regions, radioactive material work areas, all small equipment, sinks, refrigerators and freezers including their handles, telephones, light switches and doorknobs. Also pay close attention to laboratory coats, waste areas, and containers for both radioactive and ordinary trash.

Identify those areas showing count rates significantly above background levels on the survey map. Record the highest count rates for these locations on the Survey Data Sheet.

Do a wipe test of the laboratory, including the areas indicated previously. Also, take wipes of regions where high counts were found with the survey meter. Wipes may be wetted with alcohol or distilled water to increase the "lifting" ability. Typical wipe tests should be performed over a 100-cm² area.

Record the locations of the wipe tests and the area wiped on the map. Take wipes of broader areas initially but remember that for determination of contamination smaller wipes should be taken as well. Load wipes in the appropriate radioactivity counter. Record the type of counter used and its efficiency. All results distinguishable from background should be converted to units of disintegrations per minute (dpm) per 100 cm² or in $\mu\text{Ci} / 100 \text{ cm}^2$.

Following ALARA practice, it is prudent to immediately clean all areas where removable contamination was identified. Decontamination should proceed until the count rate corresponds to an activity of less than 220 dpm/100 cm². If non-removable contamination remains, contact the Radiation Safety Office.

Survey Meter Maintenance and Calibration

Policy

Authorized users are responsible for the annual calibration, maintenance and repair of their survey meters. Count rate survey meter calibrations are provided by the Radiation Safety Office as a free service.

Regulatory References

10 CFR 20.1501 (b)
RIDOH § A.3.2
Broad Scope License

Procedure

The Radiation Safety Office has the ability to calibrate most makes and models of survey meters used on campus. Before the expiration date for calibration of your meter is reached, make sure that the survey meter's batteries are in good working order and that the meter and probe are free from contamination. Then bring the meter to the Radiation Safety Office. The Radiation Safety Office checks the electronic linearity of the meter and determines meter efficiencies for the isotopes used in your laboratory. This procedure generally takes at least two working days.

Some meters cannot be calibrated by the Radiation Safety Office and must be sent by the Authorized User to an outside vendor. These are meters that need repair. Dose rate calibrations are necessary for meters used for dose measurements; count rate calibrations are necessary for meters used for contamination measurements. If your meter has been calibrated by an outside vendor, bring the meter AND a copy of its calibration certificate to the Radiation Safety Office for determination of isotope efficiencies. If there are any doubts about where to have your meter calibrated, contact the Radiation Safety Office prior to sending it to a vendor. All new meters should also be brought to the Radiation Safety Office for determination of isotope efficiencies. The Authorized User is responsible for all charges incurred for repair by a commercial vendor and for commercial calibration of meters.

Some labs protect the probe of their survey meter with cellophane or plastic caps. This practice is appropriate when using the meter to detect possible contamination occurring during the experiment. However, when carrying out contamination surveys, an UNSHIELDED probe shall be used. Protect the probe from contamination by avoiding contact with surfaces that may be contaminated. Batteries in your survey meter should be checked every time the meter is used. This is generally done by turning a switch to the "BATT" position or by pressing the button labeled "Battery Check." If the needle does not reach the "Battery OK"

range, the batteries must be replaced immediately to ensure that the meter functions properly. If you are unsure about any aspect of survey meter operation, call the Radiation Safety Office. To prevent damage from corrosion, remove the batteries from your meter if it will not be used for an extended period.

Protect the meter from bumps and drops. The crystals in a gamma detector shatter on impact, and GM probe membranes can easily become damaged, releasing the gas necessary for the meter to function. Also, the electronics in the meter box can develop loose connections. If you think your meter has been damaged, bring it to the Radiation Safety Office for evaluation. Off-campus repair may be necessary.

Posting and Labeling

Policy

All rooms and areas where regulated quantities of radioactive materials are used or stored must be posted with appropriate signs and labels to inform personnel and visitors to use caution upon entering the area. A Rhode Island Department of Health (RIDOH) "Notice to Employees" information sheet must be posted so that all employees can observe and have the opportunity to read the notice on their way to or from their work area. All postings and signage may be obtained from the Radiation Safety Office.

The signage and postings include Radiation symbol, "Caution Radioactive Materials" sign, emergency contact information, "Notice to Employees" information sheet

Regulatory References

10 CFR 20
RIDOH § A
Broad Scope License

Procedure

Work Areas:

A "Caution Radioactive Materials" sign and emergency contact information must be visibly posted for each area where licensed quantities of radioactive materials are stored or used.

An RIDOH "Notice to Employees" information sheet must be posted around laboratory areas where radioactive materials are used.

The guidelines in the Laboratory Decommissioning section of this guide must be followed before removal of labels and signs indicating the use or storage of radioactive materials.

Use of warning signs for labeling personal items is not permitted. For example, labeling a non-radioactive bookbag as "radioactive" to keep others away is not permitted.

Mark areas where radioactive materials and/or radiation levels could exist with warning signs. Use "Radiation Area" and "High Radiation Area" signs as defined below.

"Radiation Area" refers to any area accessible to personnel in which the radiation levels are such that a major portion of the body could receive a dose of 5 mRem or more in one hour or 100 mRem in any five consecutive days.

"High Radiation Area" refers to any area accessible to personnel in which the radiation levels are such that a major portion of the body could receive a dose of 100 mRem or more in one hour. Ropes or fences should be used in addition to the warning signs to clearly mark restricted areas.

Entrances: Obtain labels from the Radiation Safety Office for all entrances to areas where the storage and use of radioactive materials occurs. Entrances to a laboratory work area should have a "No Eating, Drinking, Smoking" sign and a "Caution Radioactive Materials" sign clearly visible.

Refrigerators and Freezers: Equipment used to store radioactive stock solutions and sample preparations should be prominently labeled with a "Caution Radioactive Material" sign. Refrigerators and freezers used for radioactive material storage not in a lockable lab need to be posted with emergency contact information and locked, unless a secured, lock-box is contained within. If a secured, internal lock-box is used, this information must be on the lock-box.

Sinks and waste containers: All radioactive waste containers must be labeled with isotope, activity and date. The trefoil labels must be large enough and clearly visible from all sides of the waste container. Containers of radioactive liquid waste must be doubly contained. That is, the container must be in a tray or bucket that would contain the entire volume of liquid in the event of original container's spillage or breakage. All sinks used for radioactive material disposal must be labeled with "Radioactive Material" tape. A sewer disposal log indicating isotope, activity, date, and the chemical form of each isotope disposed must be posted so that it is readily visible from the sink.

Small Laboratory Equipment: All trays, containers, racks, stock solutions, tools, etc. that contain RAM or are contaminated must be labeled with "Radioactive Material" tape indicating isotope, estimated activity, and reference date. While it is not reasonable to expect that each tube or vial be labeled, each tray or rack that holds radioactive materials and will not be constantly attended (i.e., actively used) must be labeled.

All "Radioactive Material" labels must be removed or defaced prior to disposal or removal of containers or other laboratory equipment that are no longer radioactive.

Equipment in Hallways: Equipment in hallways which may contain or which is used for working with radioactive materials (refrigerators, freezers, liquid scintillation counters, centrifuges, etc.) must be labeled "Caution Radioactive Materials." In addition, these items must be posted with an Emergency Contact

Form listing the Principal Investigator's name and emergency contact phone number.

All radioactive-labeled refrigerators, freezers or other storage units for radioactive materials in unsecured areas must have a security lock to limit access to materials or must contain a secured, labeled lock-box within. Either the storage unit or an internal lock-box should be kept locked, even if they do not contain any radioactive materials.

EXEMPTIONS TO POSTING AND LABELING REQUIREMENTS

Areas or rooms containing radioactive materials for periods of less than 8 hours are exempt from posting requirements if either of the following conditions is met:

1. Containers are attended by an individual who takes the precautions necessary to prevent the exposure of other people (less than 2 mRem in an hour at a distance of one foot) and does not involve the manipulation of open RAM;
2. Containers are in transport and are packaged and labeled in accordance with the U.S. Department of Transportation regulations.

Record Keeping

Policy

Record retention activities must conform to all applicable State and Federal regulations. Records must be kept up to date and be readily available for inspection by administrative and regulatory authorities.

Regulatory References

10CFR 20.2102, 20.2103, 20.2106f, and 20.2108
RIDOH § A.5.2, A.5.3, A.5.7, and A.5.9
10CFR 30.51 and 30.35g

Procedure

It must be possible from the documentation to establish that all conditions for the safe use of radioactive materials have been met. These records should include:

1. Receipt and disposal of radioactive material in your possession
2. Waste disposals
3. Transfer and storage, including relevant radiation survey results
4. All incident reports
5. Surveys of rooms and equipment
6. Package receipt surveys.

Records of the above items must be maintained until the appropriate regulatory authorities terminate the radioactive materials license requiring these records with the exception of records for room, equipment and package receipt surveys which must be maintained for three years.

Radioactive Material Incident Response

Policy

Each Authorized User is responsible for ensuring that the Radiation Safety Office (789-9391) during office hours (8:30 a.m. - 4:30 p.m.) or Security after hours is called immediately in the event of a major spill, theft or loss of radioactive material, personnel contamination, contamination outside a restricted area, accidental ingestion of radioactive material, or the accidental disposal of radioactive material to the normal trash.

Regulatory References

Broad Scope License

Procedure

The Authorized User is required to implement incident response procedures as part of the radioactive material use application process. Laboratory Incident Response procedures may be divided into three parts: Spill, Decontamination, and Emergency Procedures. All three are included together since they are all used in responding to incidents involving radioactive materials that are most likely to occur in a laboratory. Response procedures for other laboratory hazards (e.g., hazardous chemicals and/or pathogens) that may be present should be considered but are not included.

Spill Assessment Considerations

1. Isotope emission characteristics
2. Radioactive material volatility
3. Activity of the radioactive material involved
4. Size of contaminated area
5. Potential for spreading contamination
6. Potential external and internal dose

Spill Response

A Minor Spill is a spill that remains contained, can easily and effectively be cleaned-up without assistance from the Radiation Safety Office and does not involve personnel contamination.

1. Notify others in area of minor spill.
2. Survey hands and surrounding areas; remove gloves if required and replace gloves.
3. Remove contaminated bench paper and dispose of as radioactive waste.
4. Decontaminate and verify that all contamination is removed.
5. Re-survey immediate and surrounding areas.

A Major Spill is a spill that involves personnel contamination or results in contamination outside of the intended work area, and that cannot be promptly cleaned up.

Immediately notify Radiation Safety Office of a major spill.

1. Notify others in the area of major spill.
2. Have somebody not involved in incident (if practical) call the Radiation Safety Office for assistance and guidance.
3. Check shoes for potential contamination.
4. Have unaffected personnel (if available) survey the area for contamination boundary.
5. Barricade area at boundary of contamination to prevent spreading of contamination.
6. With assistance and replacement items, remove contaminated clothing or footwear.
7. Do not leave the area until the initial investigation by the Radiation Safety Office has been completed.

Decontamination Procedures

Floor Decontamination:

1. Put on appropriate personal protective equipment (double gloves, booties, etc.) before entering areas where there may be contamination.
2. Define outer boundary of contamination and mark off with tape.
3. As soon as possible clean from the outer edge of the contamination and work inward.
4. Use a spray solution and wipe up with paper towels or other absorbent material to remove as much removable contamination as possible.
5. Low activity spills not containing hazardous materials can be cleaned up by using soap and water, then disposing of the contaminated water down the sanitary sewer.
6. For large activity spills, shielding may be required to reduce radiation exposures, and the use of tongs will minimize hand exposure .
7. While cleaning towards the center area, check newly cleaned areas for loose contamination before walking or kneeling in these areas. Bench paper may be placed over these areas to prevent recontamination.
8. Tape off any areas where the contamination cannot be easily removed for further decontamination efforts or shielding.
9. Re-survey area.

Equipment Decontamination:

1. Use a spray cleaning solution and wipe up with paper towels or other absorbent material to remove as much of the contamination as possible.

- Be careful not to flood the area with cleaner since that will wash contamination into cracks, which will make it harder to clean up later.
2. Low activity spills not containing hazardous materials can be cleaned using soap and water, then disposed down the sanitary sewer, provided the activity does not exceed sewer disposal limits.
 3. Wash until removable contamination is gone. When wipe tests indicate only fixed contamination remains, label the instrument with isotope, activity and date.

Fume Hood Decontamination:

1. Ensure that chemical fume hood is running.
2. Remove items from hood and place on clean bench paper outside of hood, segregating contaminated items.
3. NOTE: volatile isotopes should be put into bags and sealed before removing from hood.
4. Cut out and remove contaminated bench paper from hood and remove remaining bench paper.
5. Check floor areas for contamination from transporting contaminated items.
6. Use spray and paper towels to clean removable radioactive contamination on floor of hood for low-level contamination wash with soap and water.
7. Check backside of hood sash and walls of the hood for contamination and use spray and paper towels to clean any contamination.
8. Shield and label fixed contamination with isotope, activity and date. Short-lived isotopes may be left for decay; long-lived isotopes may require destructive removal and replacement by the Radiation Safety Office.
9. Re-survey area.

Clothing Decontamination:

1. Remove the contaminated clothing carefully to avoid or minimize contaminating the skin.
2. Check the skin for possible contamination; decontaminate the skin as indicated below before continuing with clothing decontamination.
3. Determine approximate activity on the clothing.
4. If clothing contamination is less than daily sewer disposal limit, wash the clothing with soap and water in the sink, recording the sewer disposal activities, and re-survey clothing.
5. If the clothing contamination is more than the sewer disposal limit and cannot be readily cleaned, the clothing will have to be held for decay or disposed as radioactive waste.

Skin Decontamination

1. Contact Radiation Safety Office for assistance.
2. Wash with mild soap and running water (or wetted towels).

3. Do not abrade skin or scrub raw.
4. Survey after each washing and drying for cleaning efficiency.
5. When washing with soap and water no longer reduces contamination, record remaining activity on skin and apply lotion to keep skin moist and help loosen contamination.

Emergency Procedures

Most emergency response procedures involve notifying the Radiation Safety Office and Security. Security will coordinate emergency response communications and notifications with the hospital, ambulance, and fire personnel. For emergency response to spills of radioactive materials, notify the Radiation Safety Office at 789-9391 during office hours (8:30 a.m. – 4:30 p.m.) or Security after hours. Fire and Medical emergencies should be directly referred to Security at all times.

Small Fire:

1. Notify others in immediate vicinity of fire.
2. Pull local fire alarm, then call Security providing information as required.
3. Use fire extinguisher to extinguish fire if there is no personal risk.
4. Remove personal protective equipment.
5. Check yourself (especially feet) for contamination.
6. Turn off power equipment if practical.

Large Fire:

1. Notify others in immediate vicinity of fire.
2. Pull local fire alarm and call Security, providing information as required.
3. If not in immediate danger, perform the following:
 - Shut down experiment.
 - Remove personal protective equipment.
 - Check yourself (especially feet) for contamination.
 - Leave building.

Medical Emergency:

1. Identify type of medical emergency.
2. Notify others in immediate vicinity.
3. Call Security and provide information as required.
4. Check yourself (especially feet) for contamination.
5. Offer appropriate first aid and wait for Security to arrive.

6. If practical, check subject for radioactive contamination.

Do not leave the area until the initial investigation by Security has been completed.

Incidents Reportable to the Radiation Safety Office

Policy

Each Authorized User is responsible for ensuring that the Radiation Safety Office (789-9391) during office hours (8:30 a.m. - 4:30 p.m.) or Security after hours is called immediately in the event of a major spill, theft or loss of radioactive material, personnel contamination, contamination outside a restricted area, accidental ingestion of radioactive material, or the accidental disposal of radioactive material to the normal trash.

Regulatory References

10CFR 20.2201 (theft/loss)
RIDOH § A.5.12
10CFR 20.2202 (notification of incident)
RIDOH § A.5.13
10CFR 20.2203 (exceed limits)
RIDOH § A.5.14
10CFR 30.50 (reporting requirements)

Procedure

Those incidents listed above in the "Policy" section must be reported to the Radiation Safety Office. An Incident Report Form should be filled out by the Authorized User and sent to the Radiation Safety Office as soon as possible after the incident. The first part of the form includes basic information such as the name of the Authorized User, the date and time of the incident, the date and time it is reported to Security/Radiation Safety Office, the location of the incident, and the isotope and activity involved. The second part of the form consists of a written description that includes: how the incident occurred; what caused the incident; the areas, personnel, and/or equipment that were contaminated, if any; the current status; and any procedural changes required to prevent a recurrence of the incident. If the incident involved contamination of an area, equipment, or personnel, a copy of the contamination survey should be attached. This survey should include a diagram of the affected area or equipment and the results of meter and wipe tests indicating contamination levels in dpm or μCi . The original surveys should be placed in the Authorized User's file with laboratory survey records.

Inactive AU Status

Policy

The Radiation Safety Office has an Authorized User classification of “Inactive Authorized User” Status for laboratories that do not need to possess or use radioactive materials for the foreseeable future. An inactive Authorized User is relieved of the requirement to send in monthly inventories, complete laboratory contamination surveys, and attend annual retraining sessions.

Regulatory References

Broad Scope License

Procedure

To achieve “Inactive Authorized User” status:

1. Send a letter of intent to the Radiation Safety Office.
2. Dispose or transfer all radioactive materials in your possession using appropriate procedures.
3. Complete a decommissioning survey for all of your rooms not used by another Authorized User.
4. Schedule a confirmatory survey by the Radiation Safety Office.
5. Remove all radiation postings and labels after approval by the Radiation Safety Office.
6. Return all personnel dosimetry to the Radiation Safety Office.

To regain “Active Authorized User” status:

1. Send a letter to the Radiation Safety Officer requesting reactivation.
2. Update room maps with survey locations.
3. Update protocol for general radionuclide usage.
4. Update safe radionuclide handling and survey procedures.
5. Verify that survey meter instruments are within annual calibration.
6. Verify that RAM-use personnel and AU were retrained within the past year.
7. Obtain required personnel dosimetry for radioactive material use by personnel and Authorized User.
8. Request pre-startup review of laboratory procedures by the Radiation Safety Committee.

The Radiation Safety Office will assist in the replacement of all required posting/labeling.

Laboratory Decommissioning

Policy

Authorized users are responsible for the final survey of any area where radioactive materials were used or stored under their supervision. These areas shall be thoroughly checked for radioactive materials and contamination prior to being considered general laboratory space. Once a thorough survey has been completed by the laboratory and confirmed by the Radiation Safety Office, the room is no longer a restricted area, and the laboratory is decommissioned for the use of radioactive materials.

Regulatory References

Reg. Guide 8.23, Table 2.1

10 CFR 20.1003, 30.35

RIDOH § A.0

“Multi-Agency Radiation Survey and Site Investigation Manual”
(MARSSIM via NRC NUREG-1575, EPA 402-R-97-016)

Procedure

Call the Radiation Safety Office at least ten working days prior to the requested date of decommissioning. Give reasons for the decommissioning and the intended future use of the room. Request a Decommissioning Form to document that all requirements are met. If the Authorized User is leaving the University, the following laboratory records should be turned over to Radiation Safety:

1. Receipt and disposal of radioactive material in your possession
2. Waste disposals
3. Transfer and storage, including relevant radiation survey results
4. All incident reports
5. Surveys of rooms and equipment
6. Package receipt surveys.

Remove all sources of radioactivity from the lab using proper waste stream and transfer procedures. Keep all radioactive materials warning signs and postings in place. Verify that no radioactive materials are left in drawers or storage areas.

Analytical X-ray Units

Policy

Radiation exposures from x-ray diffraction or fluorescence units can be extremely hazardous. Dose rates in the primary beam can exceed 100,000R/minute. Any part of the body momentarily placed in the beam would receive enough radiation to cause serious radiation burns. X-ray diffraction machines must be operated in accordance with the following basic requirements.

Radiation exposures to individuals must be so controlled that the shallow dose equivalent, eye dose equivalent, and deep dose equivalent limits are not exceeded. In particular, personnel must not expose any part of their bodies to the primary beam.

Regulatory References

RIDOH Part E

Procedure

Operator Responsibilities

An individual will be permitted to operate an analytical x-ray unit if he/she has received radiation safety training, demonstrated competence in the safe operation of the machine and radiation survey instruments, and received the approval of the Radiation Safety Office.

The operator is responsible for all operations including radiation safety. In particular, he/she should keep radiation exposures as low as practical, observe safety precautions and procedures as they apply to each machine operated, and notify the Radiation Safety Officer of any known or suspected abnormal radiation exposures.

Operating Procedures

Written operating procedures must be readily available to the operator. The operator should be in immediate attendance at all times when the machine is in operation. When not in operation, the machine must be secured in such a way as to be inoperable to unauthorized persons.

Maintenance

Only properly trained personnel are permitted to install, repair, or make other than routine modifications to the X-ray generating apparatus and tube housing.

Beam Alignment

Procedures and apparatus utilized in beam alignment should be designed to minimize radiation exposure to the operator. Particular attention should be given to viewing devices to assure that lenses and other transparent components attenuate the radiation beam to minimal levels. When alignment involves working near the open primary X-ray beam, the beam current should be reduced in order to lower exposure rates.

If a fluorescent alignment tool is used, dimming the room light will permit a significant reduction in beam current. The fluorescent alignment tool should be long enough to permit the operator's hand to be kept at a safe distance from the beam. The operator should be familiar with the manufacturer's recommended alignment procedures, and copies of these should be available for reference.

Altering Safety Devices

If it is necessary to alter any safety device, (bypass interlocks or remove shielding):

- The actions must be authorized in advance by the Radiation Safety Office.
- The actions must be performed under the supervision of the registered user.
- The actions must be terminated as soon as possible and safety devices reinstalled.

Any attempt to bypass or alter safety devices should only be undertaken as the last resort to proceed with the research. During the bypass period, a readily discernible sign bearing the words "Safety Device Inoperable" shall be placed on the radiation source housing.

Personnel Monitoring

X-ray diffraction machine operators will wear monitoring devices (a film badge and a TLD finger ring) when:

- They are operating; or
- They are near an operating machine.

The dosimeter should be worn on the torso and the finger ring should be worn on the hand most likely to be exposed.

Area Monitoring

Users must monitor routinely for stray or scattered radiation in the immediate vicinity of the X-ray machine with an appropriate detector. Leakage radiation from the tube housing must be less than 2 millirem per hour at 5 cm and leakage from the generator cabinet must be less than 0.25 millirem per hour at 5 cm. All safety devices (interlocks, shields, shutters, cabinets, etc.) must also be checked. In addition to routine surveys, a survey must be made after each repair or modification of the apparatus. If any modification is made to the machine,

Radiation Safety Officer must be notified. Radiation levels and results of safety device checks must be recorded in the Radiation Survey Log.

Radiation protection surveys will also be conducted by Radiation Safety Office every year or upon request. Surveys by Radiation Safety Office are supplemental to the required surveys performed by the users.

High Voltage Hazards

The high voltage power supply of X-ray machines can be particularly hazardous. Personnel must never tamper with high voltage equipment. Only properly trained personnel are permitted to install, repair, or modify high voltage equipment.

Safety Engineering

The equipment should incorporate engineered safety features of a fail-safe design to prevent possible exposures:

- For open beam configurations, a safety device to prevent entry of hands and other body parts into the primary beam, or that will shut off the X-rays if the beam path is entered, must be provided.
- Unused ports must be secured so that the shutters cannot be opened unless a collimator or coupling is connected.
- Safety interlocks should be employed on tube head ports or shielding.
- The coupling between the X-ray tube and the collimator of the diffractometer, camera, or other accessory must prevent stray X-rays from escaping the coupling.

Warnings

Visual warnings must be used to indicate the potential for radiation exposure on all devices of open beam configuration:

- Easily visible flashing lights or equally conspicuous signals located near the tube housing that indicate when the X-ray tube is on or off must be provided if the primary beam is controlled in this manner.
- If the beam is controlled by shutters, a readily discernible indication of shutter status (open or closed) must be located near each port on the radiation source housing.
- The warning devices should be of a fail-safe design and must be labeled so that their purpose is easily identified.
- A red warning light with the notation "X-RAY ON" or the equivalent, should be located on the control panel, and should light only when the X-ray tube is activated.
- A sign or label bearing the words "CAUTION - RADIATION, THIS EQUIPMENT PRODUCES X-RADIATION WHEN ENERGIZED" or words having similar intent, must be placed near any switch that energizes an X-ray tube.

- A label bearing the radiation symbol and the words "CAUTION - HIGH INTENSITY X-RAY BEAM" must be placed on or adjacent to each X-ray tube housing. It should be located so as to be clearly visible to any person who may be working near the primary radiation beam.
- Each area or room containing analytical X-ray equipment must be posted with a sign bearing the radiation symbol and the words "CAUTION - X-RAY EQUIPMENT".

Tests

The user should test all safety devices (e.g., interlocks, shields, shutters, warning lights, etc.) quarterly to insure their proper operation. The tests should be recorded in the Radiation Survey Log.

Electron Microscopes

Policy

X-rays are produced by electron microscopes when the primary electron beam or back-scattered electrons strike metal parts of the microscope. X-rays are also produced during x-ray fluorescence measurements. The shielding provided by the metal casing of the microscope and leaded glass on the viewing ports is usually adequate to ensure that radiation exposure to personnel is kept to a minimum. However, there are some general principles of radiation safety that you should know about when working with or around electron microscopes.

Regulatory References

RIDOH §B.2.1

Procedure

Users shall notify the Radiation Safety Office of each newly acquired electron microscope. The Radiation Safety Office will complete an annual assessment of the dose rates.

To complete the assessment, the Radiation Safety Office may provide a dosimeter. If a dosimeter is used, the user will place the dosimeter on or immediately adjacent to the column and exchange it at specified intervals (usually monthly). The total dose for the calendar year should be less than 500 millirems.

Training

New users should be trained in the potential radiation hazards of electron microscopes.

Older Units

Modern electron microscopes are made to electronic product radiation standards and generally have adequate shielding. Users should ensure that individual units have been manufactured and assembled in accordance with applicable US Food and Drug Administration regulations. Units manufactured before the late 1960's may have significant x-ray leakage. Units manufactured before 1956 may be missing leaded glass windows and shielded intermediate viewing ports

Survey

A radiation survey for x-ray leakage should be performed:

- at time of installation;

- any time the microscope is moved, modified, or attachments/accessories are added/removed;
- when any part of the metal casing or viewing windows are removed; and/or
- if the current level is set higher than normal

Survey Conditions

Radiation surveys should be carried out under "worst case" conditions:

- highest acceleration voltage;
- highest beam current;
- beam at crossover on specimen;
- low magnification; and
- all apertures removed.

Survey Instrument

A scintillation counter can be used to detect x-ray leakage. However, the energy dependent response of a scintillation counter makes it inappropriate for measuring x-ray leakage. When measurement of x-ray leakage is desired, an appropriately calibrated air ionization chamber should be used.

Survey Technique

Move the instrument slowly allowing time for it to respond. During the survey, pay particular attention to the following parts of the microscope:

- gun;
- camera / viewing chamber;
- specimen changer;
- junctions between column sections; and
- attachment joints

Exposure Rate Guideline

The Radiation Safety Office must be notified if the x-ray exposure rates exceed 0.5 milliRem per hour at 5 centimeters from the surface of the unit.

Assistance

The Radiation Safety Office can aid in the selection of appropriate radiation survey equipment or perform radiation surveys of electron microscopes on request.

Gas Chromatograph Sources

Policy

Electron capture detectors for gas chromatographs utilize a radioactive source that usually contains either H-3 or Ni-63. Under normal operating conditions these sources present very little hazard. However, the storage, cleaning, or exchange of the sources can produce contamination and radiation hazards. Electron capture detectors shall be handled in accordance with the procedures and recommendations of the device's manufacturer.

Regulatory References

RIDOH § A.3.1

Procedure

The radioactive source, usually a metal foil, may not be removed from the detector cell, except under the supervision of Radiation Safety Office personnel.

Sources should only be cleaned according the manufacturer's instructions. Abrasives may not be used to clean foils. This will scratch the source coating on foils, allowing leakage of the radioactive material. Abrasives may also remove the Ni-63 plating or material containing H-3 from other foils. Source foils should be handled with forceps, at the edges only, to prevent scratching the foil surface.

Solutions used to clean and rinse detector cells may be contaminated and should be assayed and disposed of as radioactive waste. If foils are exchanged, the old foils are to be returned to the manufacturer or disposed of as radioactive waste.

Tritium foils or detector cells should be stored in an airtight container when not in use. The container should be opened in a fume hood to exhaust the tritiated hydrogen gas and water vapor that accumulates in the container.

Detector cells containing tritium foils may only be used in conjunction with a properly operating temperature control mechanism that prevents the foil temperature from exceeding 225⁰ C.

Gauges

Policy

Gauges are designed and licensed to do specific measuring tasks, (e.g., measure moisture and density of soils). These devices typically contain one or two radioactive sources, (e.g., an Americium-241: Beryllium (Am-Be) source and a Cesium-137 source). Each gauge will be operated and maintained in accordance with its manufacturer's manual of operation and instruction.

Regulatory References

RIDOH Part E

Procedure

Training

Gauge operators shall be trained in the proper operation and use of the gauge. Students may operate the gauge only under the supervision of a properly trained gauge operator.

Operation

Gauges may be operated only by (or under the direct supervision of) a properly trained operator. The gauge operator will maintain constant surveillance of the gauge during operation and restrict access to the immediate area of the gauge. Except when recording readings, students should remain at least two meters from the gauge when its source(s) is (are) exposed.

Storage

Gauges shall be secured against unauthorized removal of the sealed source from its fully shielded position when in storage or transit. They shall also be secured against unauthorized removal from their storage areas when not in use.

Stuck Source

If the operator is unable to retract a source, he/she should immediately notify the Radiation Safety Office (789-9391), cordon off the area around the gauge (for most URI gauges, a 15-foot radius is sufficient) and prevent unauthorized personnel from entering the area to minimize exposure. The operator should remain outside the cordoned area and maintain surveillance of the gauge.

The gauge manufacturer should be consulted if repeated attempts to retract the source are unsuccessful. The Radiation Safety Office will notify the Department

of Health if it becomes apparent that attempts to recover the source will be unsuccessful.

If the source is successfully retracted, the Radiation Safety Office should conduct a radiation survey using appropriate radiation detection instrumentation to verify that the source is properly stored.

Transport

Most URI gauges have shipping and storage containers certified as DOT packages for special form material. Those gauges shall be transported in their storage and shipping container.

The US Department of Transportation⁴ has determined that transport between university buildings in a state vehicle is not subject to the Hazardous Materials Transport Act (HMTA) regulations. However, if the gauge is transported to a field location off campus, HMTA regulations apply.

Traffic Accidents

If a gauge is involved in a traffic accident, follow the instructions provided by the gauge manufacturer in their manual, (see the manual's emergency response information). Notify the Radiation Safety Office.

If the gauge can be readily seen, visually inspect it for signs of damage. If one or more sources have been ejected from the gauge, cordon off the area and prevent unauthorized personnel from entering it.

Emergency response actions⁵ may be performed prior to any measurement of radiation. Limit entry into the immediate area of the gauge to the shortest time possible.

Labels

Most gauges have a radioactive label and an identification plate. The identification plate is usually 3-mil aluminum. It provides the type of source, serial number, activity and the date measured for the source(s).

Most gauges have a manufacturer's identification plate. The plate contains the gauge model number, serial number and the manufacturer's name and address.

⁴ Hazardous materials transported by a state employee in a state-owned vehicle between buildings at a university are not subject to the HMTA regulations. The US DOT's Office of the Chief Counsel provided the interpretation in a letter to Keith J. Schiager; USDOT dated 19 Feb. 1993.

⁵ Removal of injured personnel – Advise medical personnel that victim may be contaminated with radioactive material.

All identification labels should state “Do Not Remove” and “If Found, Notify Civil Authorities.”

Leak Tests

Only qualified personnel should test the sealed source(s) in any device for leakage. The Radiation Safety Office can assist with leak tests.

GLOSSARY OF TERMS

Absorbed dose means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy). 1 Gy = 100 rad.

Activity is the rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq). 1 Bq = 2.7×10^{-11} Ci.

ALARA (acronym for "as low as is reasonably achievable") means making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

ALI (acronym for "Annual Limit on Intake") means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rem (0.5 Sv) to any individual organ or tissue.

AU means an Authorized User.

Background radiation means radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials regulated by the Nuclear Regulatory Commission.

Becquerel is an SI unit of measurement of radioactivity equal to one transformation per second. 1 Bq = 2.7×10^{-11} Ci.

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

Byproduct material means any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Calibration is the check or correction of the accuracy of a measuring instrument to assure proper operational characteristics.

CFR means the Code of Federal Regulations

Committed dose equivalent ($H_T,50$) means the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed effective dose equivalent ($H_E,50$) is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_E,50 = \sum W_T H_T,50$)

Contamination is the deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

Controlled areas are areas, outside of restricted areas but inside the site boundary, access to which can be limited by the licensee for any reason.

CPM means Counts Per Minute.

Declared pregnant woman means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Decontamination is the reduction or removal of radioactive material from a structure, area, object, or person. Decontamination may be accomplished by treating the area to remove or reduce contamination or by allowing the radioactive material to decay.

Deep-dose equivalent (H_d), which applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

Dose equivalent (H_T) means the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv). $1 \text{ Sv} = 100 \text{ rem}$.

DOT means the United States Department of Transportation.

DPM means Disintegrations Per Minute.

Effective dose equivalent (H_E) is the sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (WT) applicable to each of the body organs or tissues that are irradiated ($H_E = \sum W_T H_T$).

EDS is Eating, Drinking, or Smoking.

Exposure means being exposed to ionizing radiation or to radioactive material.

External dose means that portion of the dose equivalent received from radiation sources outside the body.

Extremity means hand, elbow, arm below the elbow, foot, knee, or leg below the knee.

Film badge is a pack of photographic film used for approximate measurement of radiation exposure for personnel monitoring purposes.

Gray (Gy) is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rads). $1 \text{ Gy} = 100 \text{ rads}$.

High radiation areas are areas, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

IAEA means the International Atomic Energy Agency

Internal dose means that portion of the dose equivalent received from radioactive material taken into the body.

Minor means an individual less than 18 years of age.

NRC means the United States Nuclear Regulatory Commission.

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

OSL means optically stimulated luminescence. OSL dosimeters record radiation exposures using a thin layer of aluminum oxide. During analysis, the aluminum oxide is stimulated with selected frequencies of laser light, which causes it to become luminescent in proportion to the amount of its radiation exposure.

PPE means Personal Protective Equipment.

Public dose means the dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another

source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

Quality factor (Q) means the modifying factor (listed in tables I and II of RIDOH §A.1.9) that is used to derive dose equivalent from absorbed dose.

Rad is the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 Joule/kilogram (0.01 gray). 1 rad = 0.01 Gy.

Radiation areas are areas, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Radioactive Waste is radioactive material that is no longer useful.

RAM is Radioactive Material

Rem is the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem=0.01 sievert).

Restricted areas are areas, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted areas do not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

RIDOH is the Rhode Island Department of Health Rules and Regulations for the Control of Radiation

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

Shallow-dose equivalent (Hs), which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm²) averaged over an area of 1 square centimeter.

Sievert is the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv=100 rems).

Site boundary means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

Stochastic effects means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Genetic mutations and the induction of cancer are examples of stochastic effects.

Survey means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Survey meter is any portable radiation detection instrument especially adapted for inspecting an area to establish the existence and amount of radioactive material present.

TLD Thermoluminescent Dosimeter

Total Effective Dose Equivalent (TEDE) means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Unrestricted areas are areas, access to which is neither limited nor controlled by the licensee.

Unsealed source is radioactive material which is not permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal of the radioactive material.

Weighting factor (WT), for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of WT for various organs or tissue are in RIDOH § A.0.

Whole body means, for purposes of external exposure, head, trunk, (including male gonads), arms above the elbow, or legs above the knee.