UW

Radiation Safety Manual

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Radiation Safety Manual also on EH&S home page: www.ehs.washington.edu

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Section 1

Emergencies Involving Radiation

Contents

Tables

The following information is general immediate guidance for radiation accidents and emergencies.

A. Emergency Phone Numbers

1. Campus

a. Radiation Safety Office 543-0463

b. University Police..........................9-911

2. Off Campus

a. Radiation Safety Office ....(206) 543-0463

b. After hours, call University Police.......(206) 543-9331

1) Ask them to call "Staff on Call".

2) Give them your name and number.

3) Someone will call you back.

B. Personal Injury

The primary concern is care of the injured person.

1. Medical Help

Seek medical attention and inform the attendants as completely as possible regarding the incident. Someone knowledgeable should accompany the individual if they are transferred to another location for medical treatment.

2. Injury with Radiation Contamination

If the accident involves radioactive materials, there may be potential for the spread of contamination. Avoid spread of contamination as much as possible when treating the individual. However, contamination control must be considered secondary to medical care.

3. Notification

Notify the Radiation Safety Office (RSO) of the occurrence and provide the best possible description of the incident. This information may be necessary for the RSO to provide assistance to medical personnel. If unsealed radioactive material is involved, determine the radionuclide, the chemical form, an estimate of the activity, and the potential intake by the injured person.

C. Fire

Evacuate the area giving full regard to personal safety.

1. Radioactive Materials in a Fire

Do not attempt to rescue radioactive materials. Treat the incident as any other spill following control of a fire involving radioactive materials.

2. X-ray Machines or Accelerators in a Fire

Turn off radiation producing machines only if personal safety is not endangered.

D. Inhalation or Ingestion of Radioactive Materials

In the event that an individual inhales or ingests radioactive materials, immediate medical symptoms are unlikely. An exception would be if the chemical carrier of the radionuclide caused a toxic reaction.

1. Medical Attention

If the individual experiences nausea, discomfort of the mucous membranes, or other acute reactions, seek medical attention. Sometimes drinking large quantities of liquids can relieve symptoms and also dilutes activity. The need to induce vomiting or other purging procedures should be determined by a physician. RSO evaluation of intake information may be helpful to medical professionals.

2. Intake Evaluation

An attempt should be made by individuals at the site of the incident to determine the radionuclide involved, the chemical form, and an estimate of the amount inhaled or ingested. This information may be needed by an attending physician, but must also be given to the RSO for dose evaluation.

3. Dosimetry

The RSO will make an initial evaluation of the radiation dose resulting from the inhalation or ingestion event. This information may be provided to the individual or their physician, to evaluate the need for further medical response. In nearly all situations, medical intervention is not necessary due to the radioactivity alone.

4. Bioassay

Biosampling and subsequent bioassays may be necessary to refine the dosimetry estimates. Biosampling usually consists of collecting urine or feces.

E. Exposure to X-ray Machines, Accelerators or Large Gamma Sources

It is extremely unlikely that anyone would experience immediate medical symptoms from x-ray machine, accelerator or gamma source exposure. Individuals suspecting over-exposure must contact: 1) the RSO to evaluate the dose, and 2) a physician for medical follow-up.

It is important to record a detailed description of the exposure, including the position of the person, the length of exposure, intensity of the radiation, source of radiation and (if possible) an estimate of the dose delivered.

F. External Contamination to Individuals – Little or No Injury

Spills of unsealed radioactive material can often involve contamination of the skin and extremities, but usually involves little or no injury. Attention should focus on decontaminating the individual and controlling the incident. Facility or equipment decontamination can be postponed.

1. Controlling Incident

If possible, take steps to limit the spill and control access to the area.

2. Personal Decontamination

a. Protect the Eyes

Eye contamination presents a special case and the eyes should be washed with copious amounts of warm water only. An individual having eye contamination should seek medical help immediately after rinsing eyes.

b. Remove Clothing

Immediately remove contaminated articles of clothing.

c. Rinse

Rinse contaminated area with water first, then wash with mild detergent. Wash two or three minutes. If the contaminated area is extensive, use a safety shower or other available shower. Special attention should be given to areas between the fingers or toes and around the fingernails or toenails.

d. Monitor

After an initial wash, monitor the affected area.

e. Repeat Rinse

If the first wash is partially successful in removing some contamination, repeat the procedure. If little or no progress was made, follow by using a soft brush, heavy lather, and tepid water. Use care not to erode or scratch the skin. Use light pressure and wash for two or three minutes. Do not repeat any washings more than four times.

f. Maximum Skin Contamination Levels

There is no regulatory limit for skin or extremity contamination, since measures should be taken to remove as much residual contamination as possible. The following guides for acceptable levels of contamination have been proposed in radiation protection literature, but are difficult to measure. Call the Radiation Safety Office to assist in the evaluation and removal of any persistent skin contamination.

1) Alpha Emitters

Less than 150 dpm/100 cm^2, determined by direct survey of the general body and hands.

2) Beta-Gamma Emitters

Less than 0.03 mR/hr, determined by direct survey.

3) Removable Contamination

Removable contamination from the skin and extremities should be negligible, and indistinguishable from background radiation levels.

g. Contact the Radiation Safety Office

Contact the RSO to provide further assistance regarding decontamination, monitoring, dosimetry, and documentation. Do not leave the immediate area until instructed to do so by Radiation Safety staff or other qualified personnel unless attempting to receive medical attention.

G. Contamination or Spill of Radioactive Material

This section addresses contamination of equipment and facilities. See previous sections if injuries or contamination of individuals are involved.

1. Notify Authorized Investigator and Determine Hazard

Notify the Authorized Investigator or Laboratory Safety Agent responsible for the area (best authority for immediate information regarding the hazard). Determine the radionuclide(s) involved and the approximate activity. This information will be used to determine if this is a major or minor spill.

Table 1-1
Radionuclides in Use
(ALI = Annual Limit on Intake)

GROUP I ALI > 10 mCi	GROUP II 1 mCi < ALI < 10 mCi			GROUP III 0.1 mCi < ALI < 1 mCi		GROUP IV 0.01 < ALI < 0.1 mCi
H-3	C-14	Mn-54	Mo-99	Na-22	Sr-89	Sr-90
F-18	Na-24	Fe-55	In-111	P-32	Cd-109	I-125
Cr-51	P-33	Co-57	I-123	Cl-36	Ag-110m	I-131
Cu-64	S-35	Co-58	Hg-197	Ca-47	Cd-115m	
Tc-99m	K-42	Ga-67	Au-198	Fe-59	Ir-192	
In-113m	Ca-45	Hg-203 (inorganic)		Zn-65	Hg-203 (organic)	

2. Major Spills (Group I > 10 mCi / Group II > 1 mCi / Group III > .1 mCi / Group IV > .01 mCi)

a. Clear the Area

Notify all persons not involved in the spill to vacate the room.

b. Prevent the Spread

Cover the spill with absorbent pads or diatomaceous earth, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spread.

c. Shield the Source

If necessary, the spill should be shielded, but only if it can be done without further contamination or without significantly increasing your radiation exposure.

d. Close the Room

Leave the room and lock the door(s) to prevent entry.

e. Call for Help

Notify the Radiation Safety Officer immediately.

3. Minor Spills (Spills less than major spill quantities)

a. Notification

Notify persons in the area that a spill has occurred.

b. Prevent the Spread

Cover the spill with absorbent paper or pads or spread absorbent diatomaceous earth.

c. Clean-Up

Use disposable gloves. The use of remote handling tongs should also be considered whenever possible. Carefully fold the absorbent paper or pads. Scoop up absorbent diatomaceous earth with cardboard. Insert into a plastic bag and dispose in the radioactive waste container. Also, insert into the plastic bag all other contaminated materials such as disposable gloves.

d. Survey

With a low-range, thin-window Geiger-Muller (G-M) survey meter, check the area around the spill, hands, and clothing for contamination. For I-125, survey with a thin crystal sodium iodide (NaI) detector. Survey H-3, C-14, and S-35 spills with wipes counted in a liquid scintillation counter (LSC).

e. Report

Report incident to the Radiation Safety Office.

4. Decontamination Procedures

a. Prevent Spread of Contamination

The first considerations include tracking by persons, movement by air currents (hoods, fans, etc.), water, dusting, mopping, and other physical actions. To confine it, decontaminate spill from outside toward center.

b. Make a Plan

Successful decontamination calls for planned action. A spur of the moment action or premature attempt at decontamination can cause more harm than good. A prudent action is to safeguard the area while making a thorough plan of the steps to be taken in the decontamination procedure.

c. Monitoring

Make full use of instruments and available assistance. Each step of the decontamination should be monitored. One person should be kept clean to operate instruments and do other monitoring. When instruments become contaminated, any progress is compromised. Protective clothing, footwear, gloves, and respirators should be used as needed.

d. Records

Complete records should be made of the decontamination procedures.

e. Waste Disposal

Provisions must be made for disposal of cleaning solutions and contaminated articles. In some instances, it may be judged better to dispose of a contaminated article than to attempt to decontaminate.

f. Maximum Contamination Levels

Surface contamination control guidance has been proposed in the Washington Administrative Code. This guidance is offered here in simplified form:

1) Alpha Emitters (300 dpm/100 cm^2 Maximum, and 100 dpm/100 cm^2 Average)

The maximum contamination should not be on an area more than 100 cm^2 and measurement of the average contaminant should not be averaged over more than one square meter. Higher limits may be acceptable for certain alpha emitting radionuclides. Contact the Radiation Safety Office to make this determination.

2) Beta-Gamma Emitters (15,000 dpm/100 cm^2 Maximum, and 5000 dpm/100 cm^2 Average)

The maximum contamination should not be on an area more than 100 cm^2 and measurement of the average contaminant should not be averaged over more than one square meter.

3) Removable Contamination

Surfaces should be cleaned until removable contamination is negligible and cannot be distinguished from background radiation levels. If this is not possible, contact the Radiation Safety Office for additional assistance in determining removable contamination levels.

Section 2

Licensing and Regulatory Controls

Contents

Radioactive materials and radiation producing machines in the State of Washington are licensed or registered through the State of Washington Department of Health, Division of Radiation Protection. The state's authority is derived from federal legislation, state legislation, and formal agreements with federal agencies.

A. Regulations

The DOH is given authority under the Revised Code of Washington (RCW) to establish rules and regulations pertaining to the control of ionizing radiation. These regulations are contained in Title 246 of the Washington Administrative Code (WAC).

B. Radioactive Materials

The United States Nuclear Regulatory Commission (NRC) has entered into a formal agreement with the State of Washington Department of Health (DOH). This "Agreement State" status allows the state to exercise local control over the use of certain radioactive materials. Other radioactive materials not within the purview of the Agreement are controlled under state law alone. The DOH exercises this control by granting licenses for radioactive materials, promulgating regulations (closely compatible with NRC Regulations), and inspecting licensees.

1. License

The University of Washington is granted a “Type A License of Broad Scope,” often simply called a Broad License, by the DOH. The current license is numbered WN-C001-1. The Broad License allows flexibility that is essential to the function of a large education and research organization. At the same time, it requires the institution to exercise well-managed and documented internal control procedures.

2. Inspections

The DOH can inspect the University of Washington at any time to assure that it adheres to all regulations and license conditions. The inspections usually occur once each year and take 3 or more days to complete. In some years, the inspections are more frequent but shorter in duration. These inspections may include DOH visits to laboratories, hospitals, and other authorized facilities.

3. Control of work with high activity sealed sources

Work with radioactive sources containing high activities of radioactive material requires extra precautions and planning. The Radiation Safety Officer (RSO) must approve any installation, relocation, resourcing, removal, or other non-routine service of the gamma knife, any irradiator, or any other sealed source as deemed necessary by the RSO. More information is provided in Section 15.

C. Radiation Producing Machines

The DOH has also been granted authority over “radiation producing machines” within the State of Washington. Radiation producing machines generally refers to machines producing x-rays (for diagnostic medical and dental use, radiation therapy, and research), but this category also includes high-energy particle accelerators.

1. Registration

A roughly equivalent process to licensing radioactive materials is registration of radiation producing machines. The DOH requires registration and inventory of all radiation producing machines within the state. The University is currently registered to have radiation producing machines in the following areas:

- Friday Harbor Laboratory
- General Campus
- Hall Health Clinic.
- Harborview Medical Center.
- Nuclear Physics Laboratory.
- Roosevelt Clinic.
- School of Dentistry.
- School of Medicine South Lake Union

- Sports Medicine Clinic.
- University of Washington Medical Center – Montlake
- University of Washington Medical Center – Northwest
- Washington Clean Energy Testbeds

2. Inspections

As with the radioactive materials license, the DOH can inspect the University of Washington's radiation producing machines program at any time. These inspections are at variable times and may cover part or all of the registered areas.

Section 3

UW Administration

Contents

In addition to federal and state regulation of ionizing radiation, the University of Washington also provides its own administrative systems and procedures to assure proper control of radiation sources and radioactive materials.

A. Radioactive Materials License

The University of Washington's Radioactive Materials License of Broad Scope (license number WN-C001-1) is issued under authority of the State of Washington Department of Health (DOH). This license is designed to allow the University of Washington (UW) reasonable latitude for self-regulation. The issuance of a License of Broad Scope is contingent upon a satisfactory determination by the DOH of four key elements in the UW's radiation safety program:

1. Key Elements

a. Supervision

Adequate supervision and control at the administrative level.

b. Personnel

Personnel with sufficient qualifications to adequately perform proposed uses of radiation.

c. Procedures

Adequate procedures for protecting health and safety.

d. Facilities/Equipment

Suitable facilities, equipment, and associated oversight for the proposed operations.

2. Broad License

To allow the flexibility that is essential for an educational, research, and clinical institution, certain portions of the review function are delegated to the licensee. It is also required that the degree of institutional control over individual users is compatible with regulatory control that would otherwise be exercised by the DOH. Washington Administrative Code (WAC 246-235-090) indicates that a Broad License may be granted if:

> "The applicant has established administrative controls and provisions related to organization and management, procedures, record keeping, material control, and management review that are necessary to assure safe operations, including: (iii) The establishment of appropriate administrative procedures to assure: (A) Control of procurement and use of radioactive material (B) Completion of safety evaluation of proposed uses of radioactive material which takes into consideration such matters as adequacy of facilities and equipment, training and experience of the users, and the operating or handling procedures; and (C) Review, approval, and recording by the radiation safety committee of safety evaluation of proposed uses prepared in accordance with (B) of this section prior to use of the radioactive material."

B. Executive Director for Health Sciences Administration

Authority for the Radiation Safety Program at the University of Washington originates from the Board of Regents, which has full control of the University. The Board of Regents designated the UW President as the chief executive officer. The President designated the Executive Director for Health Sciences Administration as the individual responsible for advising the President about all health related activities of the UW.

The Executive Director for Health Sciences Administration has appointed the Director for the Environmental Health and Safety Department (EH&S) to provide supervision and administrative support for the radiation safety program. Also, the Executive

Director for Health Sciences Administration establishes procedures for radiation safety, and appoints the members of the University of Washington Radiation Safety Committee to give advice and be the technical and scientific lead for the radiation safety program.

C. Radiation Safety Committee

WAC 246-235-090 further states that: "Each Type A specific license of broad scope issued under this part shall be subject to the condition that radioactive material possessed under the license may only be used by, or under the direction of individuals approved by the licensee's radiation safety committee."

The Executive Director for Health Sciences Administration is the individual responsible for advising the President about all health related activities of the University. The UW Radiation Safety Committee (RSC) reports to the Executive Director of Health Sciences Administration and is charged with recommending policies and procedures with respect to radiation safety. This includes administrative controls to assure compliance with University of Washington and State of Washington requirements and regulations for use of radiation. The Committee is authorized to approve in advance either directly or through delegated authority all individual uses or categories of use of radioactive material. The Committee is further authorized to rescind that approval for cause.

1. Specific Responsibilities and Duties

The responsibilities and duties listed below are intended to provide specific guidance to the Radiation Safety Committee:

a. Responsibilities

1) Review and Approve Applications

a) Ionizing Radiation

All ionizing radiation possessed by the University of Washington, and used on or within property that is owned by, leased by, or under the control of the UW and operated by UW personnel.

b) Human Subjects

All research or experimental programs supported by or through the University of Washington, which require approval by the University Human Subjects Review Committee and involve intentional administration of radiation or radioactive materials to human experimental subjects.

c) Clinical Uses

All clinical uses of ionizing radiation, including diagnosis and therapeutic uses at hospitals or clinical facilities which are operated by UW personnel.

2) Establish Procedures

Establish procedures for review of proposals that include:

a) A critical examination of the details of the proposed use.

b) The adequacy of training and experience of users.

c) The adequacy of the equipment, facilities, and procedures.

3) Evaluate University of Washington Resources

Evaluate the adequacy of UW resources that are necessary to meet applicable regulations, especially those provided to the Department of Environmental Health and Safety.

4) Rescind Approval

Rescind approval for further use of ionizing radiation for due cause.

5) Administrative Controls

Establish necessary administrative controls to assure that there is adequate surveillance over the UW's radiation safety program.

6) Advising Executive Director

Advise the Executive Director for Health Sciences Administration and the Director for Environmental Health and Safety on matters pertaining to radiation safety.

7) Committee Procedures/Bylaws

Establish committee procedures and bylaws necessary to function effectively.

b. Duties

1) Establish Possession Limits

Establish possession limits and other specific restrictions as necessary for each individual user who is directly authorized by the RSC.

2) Specify Possession Limits

Specify possession limits and general restrictions to define those uses of ionizing radiation that are generally authorized without specific action by the RSC.

a) Specify possession limits and general restrictions to define those uses of ionizing radiation that can be authorized directly by the Radiation Safety Officer.

b) Specify possession limits and general restrictions to define those uses of ionizing radiation that can be authorized directly by the RSC Scientific Executor and the Radiation Safety Officer, acting together.

3) Restriction

Direct the Radiation Safety Officer and appropriate University of Washington officials to:

a) Immediately prohibit any uses of ionizing radiation that present either an acute health hazard or a serious violation of license conditions or UW regulations; or

b) Restrict uses of ionizing radiation that are not in compliance with either license conditions or UW regulations.

4) Reports

Review routine and special reports of the Radiation Safety Officer and initiate action as may be indicated to fulfill committee responsibilities.

5) Accidents/Incidents

Review reports of accidents and incidents for the purpose of determining causes and the means for preventing a recurrence.

6) Assist in Procedure/Policy Development

Assist in the formulation of procedures and policies for the UW radiation program.

7) Radiation Safety Manual

Review and endorse the Radiation Safety Manual.

8) Radiation Safety Officer

Participate in the selection of the Radiation Safety Officer.

9) Annual Audit

a) Conduct an annual audit of the radiation safety program which will include reviewing a report of the Radiation Safety Office operations, examining required records and written procedures, reviewing results of the State Department of Health (DOH) inspections and resulting University of Washington commitments. The audit will include an evaluation of adequacy of the UW's management control system for radiation matters. The RSC may request assistance in the performance of the audit by an outside expert in radiation safety.

b) Summarize the findings from the annual audit and report them to the Executive Director for Health Sciences Administration.

10) Delegate Authority

Delegate authority to the Radiation Safety Officer, or to the Radiation Safety Officer and the Scientific Executor working together, to approve some uses of ionizing radiation that would be needlessly delayed by a requirement for action by the full committee.

2. Frequency and Quorum for Radiation Safety Committee Meetings

The Radiation Safety Committee typically meets every other month. However, a meeting can be skipped as long as one meeting is held each calendar quarter. A meeting quorum is at least five members.

D. Radiation Safety Officer

The Radiation Safety Officer is responsible for the day-to-day coordination and management of the radiation safety program.

1. Management Reporting Structure

The Radiation Safety Officer is appointed by and reports to the Director for Environmental Health and Safety (EH&S). The Director for EH&S reports to the Executive Director for Health Sciences Administration.

2. Authority in Emergencies and Discovery of Non-Compliant Actions

Actions taken under this section will be reported to the Radiation Safety Committee and the Director for EH&S.

3. Authority to Terminate Use

a. Non-Compliance

The Radiation Safety Officer has the authority to immediately terminate the use of radiation that is:

1) Found to be a threat to health, safety, or property; or

2) Considered to be out of compliance with regulations or license conditions.

b. Improper Authorization

The Radiation Safety Officer has the authority to prevent the use of any radiation source or radioactive material that either the Radiation Safety Officer or Radiation Safety Committee has not properly authorized.

4. Authority to Impound

a. Non-Compliance

The Radiation Safety Officer has the authority to impound any radiation source or radioactive material that is:

1) Found to be a threat to health, safety, or property; or

2) Considered to be out of compliance with regulations or license conditions.

b. Improper Authorization

The Radiation Safety Officer has the authority to impound any radiation source or radioactive material that is not properly authorized by the Radiation Safety Committee or the Radiation Safety Officer.

5. Radiation Safety Staff

The Radiation Safety Officer position is a full-time assignment and is supported by a staff. The Radiation Safety (RS) staff currently consists of 6 full-time health physicists, 3 full-time technicians, 2 half-time technicians, and 2 three-quarter-time office staff.

6. Responsibilities

a. Administration

1) Manage the administrative aspects of the Radiation Safety Office (RSO), under general direction of the Director for Environmental Health and Safety (EH&S).

2) Supervise the RS staff, including offering recommendations to the Director for EH&S on hiring, promotion and disciplinary action, and conducting performance evaluations.

b. Resources and Facilities

1) Manage resources and facilities assigned to the RSO.

2) Recommend budget or other resource needs to the Director for EH&S.

c. Advising EH&S Director

1) Advise the Director for EH&S on the status of the radiation safety program.

2) Recommend action necessary to maintain the program in full compliance with regulations and license conditions.

d. Reports/Program Plan for EH&S

Provide reports and program plans as deemed necessary by the Director for EH&S to allow performance of management obligations.

e. Annual Report for Radiation Safety Committee

Provide an annual report to the Radiation Safety Committee (RSC) regarding the radiation safety program activities.

f. Approving Radiation Use

Approve the use of radiation within limits of authority delegated to the Radiation Safety Officer by the RSC.

g. Radiation Safety Manual

Revise the UW Radiation Safety Manual and administrative procedures for the radiation safety program, as needed.

h. Applications

1) Review and submit applications for the use of radiation to the RSC.

2) Prepare all applications for license amendment and negotiate the terms of license conditions in the best interest of the University of Washington.

i. Advising/Informing Radiation Safety Committee

Advise and inform the RSC on all matters not otherwise specified that should come to the attention of the RSC.

j. General Surveillance

Maintain general surveillance of overall radiation safety activities involving radiation machines and radioactive materials, including routine monitoring and special surveys of all areas where radiation work is done.

k. Compliance

Determine compliance with rules and regulations, license conditions and the conditions of project approvals specified by the RSC.

l. Receiving and Shipping Radioactive Materials

1) Receive, survey as appropriate, and deliver all shipments of radioactive material arriving for use at the University of Washington.

2) Package and ship or assist with the proper packaging and shipping of radioactive material leaving the University of Washington.

m. Radionuclide Inventory

1) Maintain an inventory of all radionuclides at the University of Washington. The inventory shall include the name of the Authorized Investigator responsible for each quantity of a radionuclide, where it will be used or stored, and the date the quantity was received and disposed by the Authorized Investigator.

2) Limit the quantity of radionuclides at the University of Washington to the amounts authorized by the license and by RSC authorizations.

n. Radioactive Waste

Supervise and coordinate the radioactive waste disposal program, including keeping waste storage and disposal records and monitoring or calculating effluents.

o. Unwanted Radioactive Materials and Devices

Assume control of radioactive materials and devices no longer needed by Authorized Investigators, including waste.

p. Personnel Monitoring

1) Distribute and arrange for processing of personnel monitoring devices.

2) Determine the need for and evaluation of bioassays.

3) Keep personnel exposure and bioassay records.

4) Notify individuals and their supervisors of exposures approaching maximum permissible amounts and recommend appropriate remedial action.

q. Instrument Calibration

1) Supervise the survey instrument calibration program, including keeping a current listing of survey instruments at the University of Washington.

2) Notify instrument owners of need for calibration.

3) Arrange for calibration of meters that are past due.

r. Sealed Sources

Supervise leak tests and inventory of sealed sources.

s. Training

Conduct training programs and otherwise instruct personnel in the proper procedures for the safe use of radioactive materials.

t. Consulting Services

Provide consulting services on all aspects of radiation protection to personnel at all levels of responsibility.

u. Decontamination

Provide consultation for decontamination, including supervision and monitoring.

v. Records

Maintain other records not specifically designated above as required by WAC 246-220-020, Records, and WAC 246-221-230, Records important to radiation safety.

7. Radiation Safety Office

The Radiation Safety Office (RSO) provides oversight to University of Washington departments using radiation to do so in a safe and legal manner. In order for the UW to meet its regulatory responsibility, the RS staff interprets regulations and establishes programs to assure their compliance.

However, a more fundamental purpose of the radiation safety program is to establish and encourage good practices so investigators satisfy basic radiation protection philosophy. That is, to conduct programs to the extent practical so occupational doses and doses to members of the public are As Low As Reasonably

Achievable (ALARA).

a. Technical and Administrative Support

Provides technical and administrative information to the Authorized Investigators. Information on campus resources or commercial systems that are unfamiliar to the Authorized Investigators may be beneficial to their programs.

b. Survey and Monitoring Program

A survey and monitoring program is a part of the RS staff's routine work. Additional surveys may be beneficial in some instances to complement laboratory programs or to assist in non-routine projects or following an incident. The Authorized investigator may request these services, but the Radiation Safety Officer will provide additional support at his/her discretion and if resources are available.

c. Training

Radiation safety training is provided in several different formats. In addition to the regularly scheduled training program, special training sessions can be scheduled for the convenience of a staff group or to address a special problem or type of work. RS staff training will not substitute for specific task training in the laboratory prior to the beginning of radiation work.

d. Shipment of Radioactive Material

Packaging and shipping services are available for radioactive material from the RS Shipping and Receiving Office. The stringent requirements of the Department of Transportation must be met in shipping radioactive material, as well as any hazardous material.

e. Radioactive Waste

Disposal of radioactive waste is an important task of RS staff. Policies on routine disposal methods are established by the Radiation Safety Office and must be followed. RS staff will work with the Authorized Investigators when special problems develop or assist in reducing costs within the standard procedures.

f. Bioassays and Internal Dose Assessments

Bioassays and internal dose assessments are provided as a routine program for some radionuclides, and by special arrangements as needs develop.

g. Personnel Dosimetry

Personnel dosimetry and external dose assessments are provided through the distribution of film badges and other dosimetry. Arrangements can be made for special measurements and area monitoring to evaluate shielding requirements or other protective measures.

h. Authorization Assistance

Assistance is available to assure that authorization criteria are understood.

i. X-ray Equipment

Safety surveys and fluoroscopic dose assessments for x-ray equipment are normally done on an annual basis to evaluate compliance with standards for radiation protection. Additional equipment evaluations and support in defining experimental dose parameters will be provided to the extent that resources are available.

Section 4

Authorization Process

Contents

The Radioactive Materials License allows the Radiation Safety Office (RSO) to issue "authorizations" which define specific conditions of radioactive material use.

A. Authorized Investigator

The RSO authorizes investigators who are affiliated with the UW to operate under the UW Radioactive Materials License of Broad Scope; these are called Authorized Investigators (AUI).

1. Criteria

The Authorized Investigator is usually a faculty member. Such investigators are legally responsible for the handling of radioactive material under their jurisdiction.

2. Authorized Investigator versus Radiation Worker

An individual who wishes to use radioactive material may seek approval as either an Authorized Investigator (AUI) or as a radiation worker. The AUI directs and supervises a project, whereas a radiation worker works under the authorization of an Authorized Investigator.

3. Authorized Investigator Responsibilities

a. Planning Experiment/Program

1) Properly plan and organize an experiment or program, with appropriate consideration to the type and amount of radiation or radioactive material involved.

2) Provide necessary equipment and controls for the safe use of radiation or radioactive material by obtaining necessary funding, specifying equipment, and assuring that all equipment is properly used and functioning.

b. Personnel

1) Provide instruction for all personnel regarding specific radiation safety requirements for the laboratories in which they will be working.

   a) Workers shall be instructed by the AUI or his/her designee in the health protection considerations associated with exposure to radiation. The extent of these instructions shall be commensurate with potential radiological health protection considerations present in their workplace.

   b) Facilitate enrollment of new personnel in the UW Radiation Safety Training program.

2) Require personnel to follow safe laboratory practices as described in this manual.

c. Radiation Detection Instruments

1) Equip each laboratory suite with appropriate survey meters or arrange for use of liquid scintillation equipment capable of detecting the types of radiation that might be encountered in the area.

2) Arrange for repair or inspection of instruments suspected of operating erratically or incorrectly.

3) Calibrate instruments at appropriate intervals.

4) Notify the Radiation Safety Office of the acquisition of new instruments.

d. Posting

1) Work with the Radiation Safety Office to post all areas under AUI control with proper radiation warning signs and notices.

2) Maintain this posting.

e. Security

Require and foster security of radioactive materials.

1) Secure radiation-producing machines, sealed sources, and concentrated stock solutions of radioactive materials when not in use. Radioactive materials can be secured in locked storage containers, provided these containers cannot be easily removed from the premises.

2) Lock laboratories when unattended.

f. Program Changes

Contact the RSO whenever changes in operational procedures, facilities, personnel, or equipment occur that may lead to changes in personnel exposure.

B. Applications to Use Radioactive Materials

1. General Laboratory Use of Radioactive Materials

An investigator seeking to become an Authorized Investigator for non-human use of radioactive material should enroll in the RS Training Class; and request an application packet from the Radiation Safety Office.

a. Application Forms

The application packet will contain the following:

1) General

Form 10 – Description of overall proposed program.

2) Personnel

Form 20 – Description of personnel training and experience in radiation work. Each person who will be working under the proposed authorization must complete a separate form.

3) Laboratory Registration

Form 50 – Description of the laboratory or workspace and the facilities in which radiation and/or radioactive materials will be used. A separate form must be completed for each space.

4) Instrument Registration

Form 51 – Description of each radiation instrument used in the program and its location. Each instrument will require a separate form.

5) A set of miscellaneous attachments, as appropriate, that may include emergency procedures, inventory record forms, laboratory survey forms, package-opening procedures, and current Radiation Safety Updates.

b. Short-Term Authorization for Visiting Scientists

Certain specialized authorizations may be granted primarily to visiting scientists and scholars who plan to use radioactive materials for a limited period of time at UW facilities or on research vessels. Appropriate training must have been completed at the individual's home institution, and documentation that such training has been received will be required.

1) Friday Harbor Lab (FHL)

Form 13 – This application form is to be used by visiting scientists to Friday Harbor Laboratory (FHL), operated by the UW Zoology Department at Friday Harbor on San Juan Island. Form 13 should be obtained from FHL and returned to them. It will be reviewed by FHL staff and then forwarded to the RSO for review and final authorization.

2) Radioactive Materials Onboard Research Vessels

Form 13V – This application form is to be used by visiting scientists, who plan to use radioactive materials onboard research vessels that are owned, leased, and/or operated by the UW.

For work planned on the RV Clifford A. Barnes or the RV Thomas A. Thompson, the application should be obtained from the UW Oceanography Department and returned to them. It will be reviewed by Oceanography staff and then forwarded to the RSO for review and final authorization.

For work that is planned on other UW vessels, the application should be obtained directly from the Radiation Safety Office.

2. Clinical Use

a. Nuclear Medicine

The medical use of radioactive materials as diagnostic tracers or for therapy for certain medical conditions shall be covered under an authorization for Clinical Use in Nuclear Medicine, and the Director of that program shall be appointed the Authorized Investigator.

Form 100 – Application for Authorization to Use Radioactive Material in a Nuclear Medicine Clinic.

b. Radiation Oncology

The medical use of radioactive sources or radiation producing machines to treat cancer shall be covered under an authorization for Clinical Use in Radiation Oncology, and the Director of that program shall be the appointed Authorized Investigator.

Form 101 – Application for Authorization to Use Radioactive Material in Radiation Oncology.

3. Sealed Source Use

a. Definition

“Sealed source” means any device containing radioactive material to be used as a source of radiation, which has been constructed in such a manner as to prevent the escape of any radioactive material. For example, sealed sources may be used in irradiators, electron-capture detectors of gas chromatographs, static elimination devices, and many other applications.

b. Training

In many cases, the risks from small sealed sources may be very slight and workers would not be expected to get a measurable occupational dose. Personnel working with sealed sources need to have training commensurate with the risks of the materials they will be using or to which they may be exposed, but they may not always be required to take the UW Radiation Safety Training program. Consult with the RSO regarding appropriate instruction for sealed source use.

c. Application Forms

An investigator seeking to become an AUI for non-human use of radioactive sealed sources should request an application packet from the RSO. The packet will contain the following:

1) General

Form 11 – Description of overall proposed program.

2) Personnel

Form 20 – Description of personnel training and experience in radiation work. Each person who will be working under the proposed authorization must complete a separate form.

3) Depending on the program, other forms or attachments, as appropriate, may be required.

4. Broad Authorization

Under certain limited conditions, a Broad Authorization may be granted for programs in which the involved personnel have a high degree of knowledge, expertise, and training in the use of radioactive materials, and their program is wide-ranging in the use of those materials.

Once a Broad Authorization is in place, changes or additions to that program may be requested using either Form 12, Application for Individual Use under a Broad Authorization, or Form 14, Amendment to Use Additional Radionuclide(s).

C. Human Subjects Applications

Research involving human subject volunteers at the UW must be reviewed and approved by the Human Subjects Review Committee. If such research involves the exposure of subjects to radiation or radioactive materials, the UW Radiation Safety Committee (RSC) must also review each protocol, focusing on protecting and informing the subjects enrolling in the protocol. The RSC must be convinced that the radiation dose to the subjects is as low as possible (without compromising the outcome of the research or the quality of the medical care received by the subjects), and that the scientific merit of the proposal justifies the risk to the subjects.

1. Authorization Criteria for Human Subjects Research

A faculty member seeking to become an Authorized Investigator for research involving the use of radiation in human subjects must first meet certain criteria.

a. Health Care Practitioner

For human subjects work with radioactive materials, medical or dental diagnostic x-rays, or therapeutic radiation, the AUI/HS is usually a health care practitioner licensed by the State of Washington, and the proposed use of radiation must be within the scope of the practitioner's license.

b. Collaboration with a Health Care Practitioner

A person, who is the principal investigator in a research program, but not a licensed health care practitioner, may be approved as an AUI/HS if the actual administration of radiation is under the authorization of a licensed health care practitioner named in the application as a collaborator. The radiation use in these studies must be standard clinical procedures that are within the scope of the collaborator's licensed practice.

c. Authorization to Cover Use of Radioactive Materials

Either an active and appropriate Radioactive Materials Authorization or a Clinical Authorization must also be in effect to cover the use of radioactive materials used in the protocol. Such authorization should be in effect for the principal investigator or for a collaborator on the study.

2. Application Forms

a. General (Long Form)

Form 30 – Application for Authorization to Use Radiation with Human Subjects at University of Washington Licensed Facilities. This is the general form that can be used for any protocol, and covers the use of radioactive materials, x-rays, and fluoroscopy.

b. Short Form

Form 31 – Short Form Application for Authorization to Use Radiation with Human Subjects at University of Washington Licensed Facilities. This form is to be used only when there are no subjects less than 18 years old involved in the study and when the radiation is only in the form of x-rays (this includes CT scans, but excludes fluoroscopy).

c. Renewal

Form 32 – Renewal Application for Authorization to Use Radiation with Human Subjects at University of Washington Licensed Facilities. This form is used to apply for annual review of studies that have been approved but will extend longer than one year.

3. Annual Review

As with the Human Subjects Review Committee, all human subjects research studies must be reviewed by the RSC on an annual basis.

D. Review of Initial Application

The completed application must be submitted to the RSO. Part of the review process is an evaluation of the appropriateness of the facilities and equipment to be used. The review includes an interview with the applicant to discuss various details of the project and radiation safety considerations.

E. Approval

Some experimental protocols involving large amounts of radioactive material or the use of radiation or radioactive material in humans may need to be presented to the RSC for full approval. However, a degree of latitude has been granted by the State of Washington Department of Health to allow the RSC to delegate some approvals of certain specific uses. For example, the Radiation Safety Officer acting alone may approve most laboratory use of radioactive materials in millicurie quantities or less. The Radiation Safety Officer and Scientific Executor acting together may approve some other specific uses of radioactive material and specific clinical applications of radiation. The entire RSC may still choose to review any authorization.

If an application is approved, the authorization form is signed and forwarded to the Authorized Investigator

F. Renewal

1. General Laboratory or Sealed Source Use

The Radiation Safety Officer and the Scientific Executor, acting together, may renew any authorization for laboratory work that was initially approved, according to current practices and criteria. At the discretion of the Radiation Safety Officer and Scientific Executor, the renewal may be referred to the full committee.

2. Human Subjects

The Radiation Safety Officer and the Scientific Executor, acting together, may renew four consecutive annual renewals of any authorization that involves the administration of radiation to human subjects. The Radiation Safety Officer, acting alone, may approve the renewal of any authorization for a research study that involves the administration of radiation to human subjects, in which no subjects have yet been enrolled.

G. Non-Approval of an Application

If approval of a project is not granted, a written notification, including an explanation for the decision, is forwarded to the applicant. The notification may contain a description of the possible modifications to the project that would be necessary for it to be approved.

1. Appeal Process

An appeal of any decision of the UW Radiation Safety Committee (UWRSC) or a decision of the Radiation Safety Officer and/or the Scientific Executor, which is made within the delegated authority of the UWRSC, can be made to the UWRSC.

a. Basis

An appeal of a UWRSC decision may be initiated for any of the following reasons:

1) The applicant considered the decision improper.

2) The decision was considered improper by a minority of the RSC.

3) Other persons who have a qualified interest in the decision considered the decision improper.

b. Submittal

An individual effected by a UWRSC decision, a UWRSC member, or a person who has a qualified interest in the decision, should present an appeal to the Chairman of the RSC. The appeal must be in writing and include additional supporting information or specific arguments in rebuttal to the Committee's explanation of the decision.

c. Processing

At the discretion of the Chairman, with the advice of the Scientific Executor, the Chairman must either return the matter to the UWRSC to be reheard or present the appeal to the Executive Director of Health Sciences Administration.

d. Second Hearing

If a second hearing by the UWRSC results in a continuing basis for appeal, the appellant should request that the Chairman present the issue to the Executive Director of Health Sciences Administration.

2. Limitation of Appeal

UWRSC action to deny use of radiation is normally final. However, the Executive Director of Health Sciences Administration may refer the action back to the committee if proper procedures were not followed.

H. Amendments

Requested changes will be subject to the same review and approval process as was the original application. The Authorized Investigator is notified of the approval of a change through an amendment to his or her authorization.

1. Major Changes

If an AUI wishes to make several major changes to his or her authorization, it may be necessary to conduct a review of the entire program. The decision as to whether or not a complete review is necessary will be made by the RSO.

2. Forms

An Authorized Investigator may request changes to his or her authorization by submitting the requested change in writing or by email. For many changes, the appropriate form should also be submitted.

a. Radionuclide

Form 14 – Used to request authorization for a new radionuclide, new physical/chemical form of a previously approved radionuclide, or an increase in the possession limit for a previously approved radionuclide.

Requests to delete a radionuclide from the list of allowed radionuclides, may be accomplished by memo or email.

b. Personnel

Form 20 – Used to add a participant to the authorization. The AUI may inform the RSO of personnel terminations via memo or email.

c. Laboratory Registration

1) New Lab

Form 50 – Used to request the addition of a new laboratory or work space. A separate form must be completed for each space.

2) Revision of Use within a Lab

Form 50R – Used to revise conditions of use within a previously certified laboratory. This form will also be required as part of any major review of an authorization.

3) Inactivation/Termination

Requests to inactivate or terminate laboratories may be accomplished by memo or email.

d. Instrument Registration

Form 51 – Used to add a new radiation detection instrument to the authorization. A separate form must be filled out for each instrument.

I. Termination/Inactivation of Authorization

Prior to closing a laboratory or other area where radionuclides have been used or stored, the Authorized Investigator must develop a plan for terminating or inactivating these areas. Termination refers to the decommissioning of laboratory space that will no longer be under the control of the Authorized Investigator or perhaps even the University. Inactivation means that the Authorized Investigator retains control of the laboratory space, yet does not have current need to use radioactive materials in his/her research program.

1. Notification

Prior to termination or inactivation, advance notification must be given to the Radiation Safety Office. RS staff needs to arrange for some coordination and oversight. This is especially important for facilities where UW possession of the property is being relinquished. In this situation, the State of Washington DOH will need to be involved with decommissioning activities. Other offices within UW Environmental Health and Safety Department also need advance notification for decommissioning activities, such as chemical disposal.

2. Transfer

The Authorized Investigator must arrange for the transfer of any remaining radioactive materials to another Authorized Investigator, or apply for the use of another space using RSO Form 50.

3. Decontamination

Decontaminate all laboratory surfaces to levels suitable for unrestricted release. See Section 1 - Emergencies Involving Radiation for acceptable residual contamination levels.

4. Termination Survey

A final termination survey must be done after all radiation use has ceased and decontamination has been completed. Records documenting the level of remaining contamination must be generated. RS staff will also do a confirmation survey after termination.

5. Financial Responsibility

The Department under which the Authorized Investigator is employed will be held responsible for any costs associated with additional decontamination or disposal or equipment and waste to facilitate unconditional release.

J. Radiation Worker

A radiation worker is a person listed on an authorization and who is allowed to work independently with radioactive materials under an Authorized Investigator.

1. Application

Any person who wishes to be approved as a radiation worker must submit a completed Form 20 to the Radiation Safety Office. Note that this application must be submitted only with the knowledge of the Authorized Investigator.

A Form 20 may be submitted for an individual at the time of the Authorized Investigator's initial application for project approval or at any time thereafter. The Authorized Investigator will be notified of the approval of personnel additions to his or her project through an amended authorization.

2. Training

Almost every radiation worker at the University of Washington must take the Radiation Safety Training Course given by the Radiation Safety Office. The exceptions are some users of sealed sources and certain individuals in clinical programs that have received extensive and specialized training in handling radioactive materials. This training is in addition to job specific training required to be given by the Authorized Investigator or his/her designee (see Section 5 - Training).

a. New Authorization

A new Authorized Investigator and the staff that will be put on the authorization must take the UW Radiation Safety Training Course before a new authorization will be approved.

b. Existing Authorization

Before being added to an authorization to use radioactive materials as a certified radiation worker, an individual must first complete the UW Radiation Safety Training Course.

Section 5

Radiation Safety Training

Contents

This section covers training for individuals working in or frequenting areas where radioactive materials are used.

A. Individuals Directly Using Radioactive Materials

1. Regulations for Training

a. Training for Safe Work Practices

State and federal regulations require that individuals who work with radioactive material be provided with sufficient training to enable them to conduct their work safely. This training must include information on the potential hazards associated with the use of radioactive material, health protection considerations, and precautions or procedures to minimize exposure. In addition, training at the University of Washington includes information regarding worker's rights, emergency procedures, and institutional procedures for the procurement, use, and disposal of radioactive material. This training meets the Washington Administrative Code requirements for radiation protection instruction to workers. Records of this training are kept in the UW Radiation Safety Office.

b. Training for Specific Laboratories

It is also recommended that each Authorized Investigator provide instructions to all personnel on specific radiation safety concerns for the particular laboratories in which they will be working. This training should be directly related to the duties of the individual, and commensurate with the risks. Documentation of this training must be maintained by the Authorized Investigator.

2. UW Training Courses

All individuals who handle radioactive materials at any UW facility must be trained in radiation safety. The training will be commensurate with the activities they perform.

All UW Radiation Safety Training Courses are available on the EH&S website Training Page. Search for the training course titles provided below.

a. Initial Radiation Safety Training

All individuals who will work independently with radioactive materials must first complete the applicable UW Radiation Safety Training course. Only those persons who have completed the applicable training course will be certified as radiation workers and listed on an authorization.

1) Radiation Safety Training for Research Laboratory Use

This training is required for all individuals working directly with radioactive material in a research laboratory. The training must be completed prior to an individual beginning work with radioactive material.

The training consists of several online modules on general radiation safety, and a final online lecture and exam on UW-specific radiation safety. Topics include basic radiation physics, biological effects of ionizing radiation, radiation survey techniques, waste disposal, UW Policies, and State Rules & Regulations.

2) Radiation Safety Training for Sealed Source Use

This training is required for all new users of radioactive sealed sources at UW. Sealed and plated sources consist of radioactive material that is either encased in metal or plastic (sealed sources) or radioactive material that has been plated as a thin film onto metal or plastic (plated sources). The training must be completed prior to an individual beginning work with radioactive sealed sources.

The training consists of four modules. The first three teach radiological fundamentals, regulations and oversight, and biological effects of radiation. The fourth module focuses on the safe use of sealed sources at the University of Washington. This training focuses on exposure control, ALARA (as low as reasonably achievable) concepts, utilizing time, distance, and shielding to reduce external dose, and UW specific policies for ordering and disposing of sealed sources.

3) Radiation Safety Training for Uranium Use

This training is required for all users of uranium compounds (e.g., electron microcopy) at UW. The training must be completed prior to an individual beginning work with radioactive sealed sources.

The training consists of four modules. The first three teach radiological fundamentals, regulations and oversight, and biological effects of radiation. The fourth module focuses on the safe use of uranium compounds at the University of Washington, specifically performing contamination surveys, and ordering and disposing of uranium compounds.

b. Refresher Radiation Safety Training

Radiation Safety Refresher Training is required annually for individuals who have completed initial Radiation Safety Training. The Authorized Investigator is responsible to ensure all individuals listed on the authorization, including the Authorized Investigator, complete the refresher training within the time-period specified by Radiation Safety. Non-compliance will result in restriction of the authorization until all workers on the authorization complete the training. Continued non-compliance may result in termination of the authorization as deemed appropriate by the RSC.

Any individual who requests to be added to an authorization, who has previously completed initial Radiation Safety Training, must complete Radiation Safety Refresher Training prior to being added to the authorization.

3. Previously Trained Personnel

Individuals who have completed radiation safety training at another institution can provide proof of training to Radiation Safety to bypass some of the online modules at Radiation Safety’s discretion. However, it is still recommended these individuals become familiar with the online radiation safety training modules. Test-out options allow for completion of training on a compressed timeline.

Certain professions receive extensive training on radiation interactions and radiation safety principles. Examples include Health Physicists, Medical Physicists, Board-Certified Radiologists and Radiation Oncologists, Nuclear Medicine Physicians, and Nuclear Medicine Technologist. Individuals with significant training, experience, and/or certification may be exempt from all or some of training requirements. This determination is made on a case-by-case basis by the Radiation Safety Officer.

B. Individuals Not Directly Using Radioactive Materials

Washington Administrative Code 246-221-140 requires instruction for individuals working in or frequenting any portion of a "restricted area." The Code also defines a restricted area (WAC 246-220-010):

> "Restricted Area - means any area to which access is limited by the licensee or registrant for purposes of protecting individuals against undue risks from exposure to radiation and radioactive material."

At the University of Washington, there are very few areas where access is limited for these reasons. Nearly all of the laboratories where radioactive materials are used are conducting biomedical research. Very small amounts of radioactive material are used and "undue risks" from these materials are not encountered. Often, the risks from associated biohazards and chemicals will far outweigh the radiation risks. These laboratories are not considered restricted areas for radiation protection purposes, and the likelihood of receiving a measurable dose is highly improbable.

Therefore, if individuals frequent or work in research laboratories yet do not directly handle radioactive materials, they do not need training as radiation workers. A determination about training for individuals allowed access to other areas, where "undue risks" may be present, will be made by Radiation Safety.

Radiation awareness training is available upon request. Please contact Radiation Safety for more information.

Section 6

Personnel Exposure and Monitoring

Contents

A. Radiation Dosimetry

Radiation dosimetry concepts and units are not rigorously defined in this manual. Attempts are made to keep explanations in general terms. Regulatory descriptions and formulas are contained in the Washington Administrative Code (WAC) 246-220

1. Absorbed Dose (Dose)

Strictly, the term dose refers to the concept of absorbed dose. This is the amount of energy absorbed per unit mass of material. The traditional unit of absorbed dose is the rad (100 erg/gram), but this unit has been superseded by the International System (SI) unit called the gray (1 Gy = 1 Joule/Kg). Conversion between energy and mass units yields the relationship between gray and rad (1 Gy = 100 rad). Modern dosimetry employs some other concepts related to absorbed dose, yet modified to account for biological effects and partial body irradiation.

2. Dose Equivalent

Dose equivalent is a concept that attempts to account for the different biological consequences resulting from different types and energies of radiation at the same absorbed dose. For example, one gray of alpha particle radiation is more damaging to human tissue than one gray of x-rays. To apply this concept, the absorbed dose (in gray or rad) is multiplied by a quality factor (Q) related to the damaging ability of the radiation. A quality factor of 1 is given to x-rays, gamma rays, and beta particles. Alpha particles are given a quality factor of 20, and neutrons of unknown energy are given a quality factor of 10. The resulting units of dose equivalent are called the rem in traditional units and the sievert (Sv) in SI units. One sievert is equal to 100 rem.

3. Deep Dose Equivalent

The deep dose equivalent is a concept that applies to external whole body radiation. It is the dose equivalent at a tissue depth of 1 centimeter. This quantity is usually determined using a "whole body" dosimeter. It does not apply to weakly penetrating radiation such as alpha particles or low-energy electrons. Units of deep dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

4. Lens Dose Equivalent

The lens dose equivalent applies to external exposure to the lens of the eye. It is the dose equivalent at a tissue depth of 0.3 centimeters. This quantity is usually determined using a "whole body" dosimeter worn at or near the collar level. It does not apply to weakly penetrating radiation such as alpha particles or low-energy electrons. Units of lens dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

5. Shallow Dose Equivalent

The shallow dose equivalent applies to external exposure of the skin of the whole body or the skin of an extremity. It is the dose equivalent just below the cornified layer of the skin at a tissue depth of 0.007 centimeter averaged over an area of 10 square centimeters. Units of shallow dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

6. Committed Dose Equivalent

The committed dose equivalent is the dose equivalent to individual internal organs or tissues that will be received from an intake of radioactive material into the body. Committed Dose Equivalent is rarely directly measurable and must be inferred by external measurement or calculated estimates. Units of committed dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

7. Total Organ Dose Equivalent

The total organ dose equivalent is the sum of the deep dose equivalent from external radiation and the committed dose equivalent to the organ or tissue receiving the highest dose equivalent. Units of total organ dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

8. Effective Dose Equivalent

In situations where only portions of the body are irradiated, it would be nice to express the expected risk in a consistent manner, no matter which portion of the body was irradiated. A concept was developed to convey this risk as an overall risk to the whole body, resulting from partial body irradiation. This is accomplished by assigning the individual a weighted average of organ dose equivalents, called "effective" dose equivalent. Procedures for calculating the effective dose equivalent are described in the Washington Administrative Code (WAC 246-220). Units of effective dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

9. Committed Effective Dose Equivalent

The committed effective dose equivalent is similar to effective dose equivalent, but applies to long-term irradiation of individual organs or tissues resulting from inhalation or ingestion of long-lived radioactive material. In these situations, the total dose is delivered slowly over long periods of time (perhaps years or even a working lifetime). The committed effective dose equivalent is the calculated 50-year total life-long effective dose equivalent resulting from an intake that will be "committed" to the individual. This "commitment" is assigned in the year the intake occurs, although it is recognized the effective dose equivalent will continue to accumulate. Units of committed effective dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

10. Total Effective Dose Equivalent

The total effective dose equivalent is the sum of the deep dose equivalent for external radiation and the committed effective dose equivalent for internal radiation. Units of total effective dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

B. Dose Limits

Dose Limits are promulgated in the Washington Administrative Code (WAC 246-221). These limits were determined by national and international agencies after careful consideration of the best available information on the biological effects of radiation. The current prudent assumption is that any dose, no matter how small, might cause some degree of harm. Therefore, a radiation dose limit does not identify a line of demarcation between "safe" and "dangerous". Instead, current dose limits are set to assure that short-term effects of radiation are avoided, and the risk of long term effects (induction of cancer, genetic effects, and effects on the fetus) are held to an acceptable level.

1. Occupational Dose Limits for Adults

The annual limit for adult occupational dose is the more limiting of:

The total effective dose equivalent being equal to 0.05 Sv (5 rem); or
The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 0.5 Sv (50 rem).

The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities are:

A lens dose equivalent of 0.15 Sv (15 rem); and
A shallow dose equivalent of 0.5 Sv (50 rem) to the skin of the whole body or to the skin of any extremity.

2. Occupational Dose Limits for Minors

Occupationally exposed individuals under the age of 18 must not receive a dose in excess of 10 percent of the annual occupational dose equivalent specified above for adults.

3. Occupational Dose Equivalent to an Embryo or Fetus

The dose equivalent to an embryo or fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, must not exceed 5 mSv (0.5 rem).

4. Non-Occupational Dose Limits

The total effective dose equivalent to individual members of the public from UW licensed or registered operations must not exceed 1 mSv (0.1 rem) in a year.

The dose in any unrestricted (public) area from external sources must not exceed 0.02 mSv (0.002 rem) in any one hour.

C. Declared Pregnant Worker

If you are a radiation worker and are pregnant, you should know that you have the option of declaring your pregnancy in writing to the Radiation Safety Office to take advantage of voluntary limits for dose to the embryo/fetus.

1. Radiation Exposure during Pregnancy

Radiation is one of many environmental factors that can affect the long-term health of an individual exposed while in the uterus. Other factors that you should consider include diet, smoking, exercise, stress, and exposure to hazardous chemicals.

The risk from radiation exposure is dependent upon the amount of exposure. The exposures allowed for declared pregnant workers are small (500 mrem over the pregnancy), and the resulting risk is extremely small compared to other risks that are always present during a pregnancy. Although it is prudent to keep occupational radiation doses low during your pregnancy, remember that this will not affect the risks that are not related to radiation.

2. Prenatal Radiation Effects

The effects of radiation exposure on the fetus are clearly dependent upon the magnitude of the radiation exposure. For perspective, the following is a discussion of radiation risks for various exposure levels.

a. Prenatal Exposures Below 500 mrem (the voluntary fetal dose limits)

There is no indication from scientific studies that harm to the fetus can result from these levels of prenatal radiation exposure. However, harm has been demonstrated at much higher doses. So, caution is wise. Pregnant workers are encouraged to voluntarily comply with a 500 mrem limit for the duration of the pregnancy.

b. Prenatal Exposures - 500 to 5,000 mrem (up to the occupational limits for adult radiation workers)

1) There are no observable effects on the growth or development of the embryo or fetus in this dose range. Exposure to radiation has not been associated with birth defects, miscarriages or other abnormalities for fetal exposures at these levels.

2) There may be an increased risk of cancer later in life for those exposed prenatally to radiation at these levels (500 to 5,000 mrem). Several studies of children exposed prenatally to diagnostic x-rays (pelvimetry) between 1940 and 1960 have shown an elevated risk of childhood leukemia and other cancers. It has been suggested that factors other than radiation may account for this increase, since the x-rays were often taken because of medical problems that increase the risk of cancer (for example, a maternal history of miscarriages or maternal age over 40). Even if these studies are inconclusive, it is prudent to assume that a risk of cancer may exist from prenatal irradiation in this dose range (500-5,000 mrem).

c. Higher Exposures - 5,000 to 50,000 mrem

Fetal exposures in excess of 5,000 mrem are very unlikely because of existing occupational limits for radiation exposure.

1) Mental Retardation

Within this region is the possible threshold for an increased incidence of mental retardation and other central nervous system abnormalities. This threshold has been estimated as occurring between 10,000 to 25,000 mrem.

2) Early Lethality

This region (5,000 to 50,000 mrem) is also the possible threshold for early lethality to the embryo in the 0-4 week gestational period. This has been documented in mice, but has not for humans.

3) Risk of Cancer

It is very likely that some risk of cancer exists from prenatal exposures between 5,000 and 50,000 mrem. The increase in cancer risk can only be conclusively documented for prenatal exposures greater than 50,000 mrem, but probably exists to a lesser degree in this dose range as well.

d. Very High Exposures - Above 50,000 mrem

1) 50,000 to 100,000 mrem

For fetal exposures greater than 50,000 mrem (such as in the atomic bomb survivors), there is a marked increase in the incidence of severe mental retardation and small head size (microcephaly). Exposures at levels greater than 50,000 mrem also produced a detectable increase in the cancer rate of atomic bomb survivors whom were irradiated prenatally.

2) Greater Than 100,000 mrem

Fetal exposures greater than 100,000 mrem led to a very high degree (possibly 60%) of miscarriages and neonatal deaths after Hiroshima. The percentage of severe mental retardation and microcephaly among surviving fetuses was high at this level. Doses over 100,000 mrem also caused radiation sickness in adults.

3. Reducing Potential for Large Exposures to the Fetus

To avoid situations where the occupational dose limits could be exceeded, abstention from or extreme caution should be used if a declared pregnant worker participates in the following activities:

a. Radioactive Iodine

Handling large (>1 millicurie) quantities of radioactive iodine in unsealed form.

b. Accelerator/Cyclotron

Performing maintenance procedures involving particle accelerator or cyclotron targets.

c. Fluoroscopy

Standing directly in a x-ray field during fluoroscopic procedures. Use of a lead apron is adequate for protection if the worker's torso remains out of the direct x-ray beam path. However, extra caution is necessary.

4. Declaring Pregnancy

State and Federal regulations allow you to reduce your occupational exposures to below 500 mrem during pregnancy by declaring this in writing to the Radiation Safety Office. The 500 mrem voluntary gestational limit is 10% of the normal occupational limit for radiation workers. Because the risk is believed to be small even at the 5,000 mrem occupational limits for nonpregnant workers, the declaration of pregnancy is voluntary. After pregnancy is declared, the 500 mrem limit becomes a requirement.

a. Evaluating Need to Declare Pregnancy

One guideline to consider is the occupational dose you receive in a year. If you are not a radiation worker, there is no need to declare pregnancy. If you are a radiation worker who receives less than 50 mrem whole-body dose in a year, you do not need to declare pregnancy.

1) If you are not currently monitored for radiation exposure (either through a whole body dosimeter, TLD ring, or bioassay), you probably receive less than this amount.

2) If you work with radionuclides, such as tritium, carbon-14, and phosphorus-32, which do not emit penetrating gamma radiation, the use of good laboratory practices (so that you do not ingest radioactive materials) would be sufficient to protect the fetus.

3) If you work with small quantities of gamma emitting radionuclides, your doses may still be far below the limit for declared pregnant workers.

4) If you have questions about your occupational radiation exposure, consult the monthly radiation exposure reports or call the Radiation Safety Office (RSO) at 543-0463.

b. Formal Declaration of Pregnancy

Since this is a formal request to change your occupational dose limits, you must submit the proper information to the Radiation Safety Office.

1) To declare a pregnancy, request the application form(s) from the Radiation Safety Office. The forms become part of the radiation dosimetry records and are required for compliance with State and Federal regulations for dosimetry record keeping. The forms must be filled out completely so that the appropriate doses may be assigned for the duration of the pregnancy.

2) If you already have a dosimeter:

   RSO Form 9 (Request for Fetal Dosimeter) may be obtained from the Area Dosimetry Coordinator (ADC) in your area or the Radiation Safety Office at 543-0463.

3) If you are a radiation worker who does not have a dosimeter, but still wish to declare pregnancy:

   Call the Radiation Safety Office to ask for:
   - RSO Form 7 - Request for Radiation Worker Dosimetry, and
   - RSO Form 9 - Request for Fetal Dosimeter.

5. Not Declaring Pregnancy

If no written declaration by a radiation worker is made concerning pregnancy, the normal occupational dose limit of 5,000 mrem per year (deep dose equivalent) remains applicable.

If you decide not to declare pregnancy or if you have already had children while working as a radiation worker, there is no undue cause for concern. The voluntary limit of 500 mrem is a means to further minimize risks. It is not a line between “safe” and “dangerous.” However, radiation workers who are concerned about the potential health effects of radiation during pregnancy are highly encouraged to take advantage of the lower limits for fetal dose.

6. Estimating Fetal Dose Equivalent

Radiation workers who declare pregnancy receive a “fetal dosimeter” in addition to their regular whole body dosimeter or TLD ring.

a. Position

The fetal dosimeter is worn at the waist level.

b. Lead Apron

If a lead apron is worn (as for workers using fluoroscopic x-ray equipment), the fetal dosimeter is to be worn under the lead apron and the regular dosimeter is to be worn outside the lead apron at the collar level. Please pay special attention to not get the two dosimeters confused and switch locations.

c. Monthly Exchange

The dosimeter is exchanged monthly, whenever you receive a new whole body dosimeter or TLD ring from your Area Dosimetry Coordinator (ADC).

If you do not have a dosimeter prior to your declaration of pregnancy, your workplace may not have an ADC. The Radiation Safety Office will provide instructions for handling the dosimeters when the dosimeters are first issued.

d. Measure of External Radiation

The fetal dosimeter only measures external radiation. It is not a substitute for bioassays (thyroid scans for workers using > 1 mCi of radioactive iodine in volatile form).

If you are a declared pregnant worker using radioactive iodine, please call the Radiation Safety Lab (206-543-6328) to ensure that you receive bioassay measurements.

7. Compliance with Occupational Exposure Limits

Once a pregnancy has been declared, it is very important to stay within the 500 mrem gestational limit. Declaring pregnancy is optional, but the 500 mrem limit becomes a legal requirement once your pregnancy is declared.

a. Notifying the Radiation Safety Office

It is a declared pregnant worker’s responsibility to contact the Radiation Safety Office if she knows that she might exceed the 500 mrem limit or routinely receive more than 50 mrem per month. Without this information, it will not always be possible for the Radiation Safety Office to identify the potential for exceeding the 500 mrem limit.

This is especially important if you think that your dose may be increased as the result of changes in the work environment, work schedule, or job rotation.

b. Job Modification

If it is determined that a job modification is necessary to comply with the limit of 500 mrem, the Radiation Safety Office will contact UW Personnel Services to help the employee and supervisor arrange for a satisfactory accommodation of the exposure conditions.

It is your supervisor's responsibility to accommodate a declaration of pregnancy and the resulting limitation on occupational dose. Exceeding this limit would cause the UW to violate the terms of its Radioactive Materials License and the State Radiation Protection Standards (WAC 246-221-055).

1) It may be possible to stay within the 500 mrem limit by making relatively minor changes in the work environment.

2) In rare instances, it may be necessary to restructure or reassign job duties, make changes in your work schedule, or arrange for a leave of absence. Such changes would be arranged through the Human Resources representative for your department, under the same rules that allow for accommodation due to temporary disabilities.

3) If you have any questions about your options for reducing your occupational dose below the 500 mrem gestational limit, please contact the Radiation Safety Office (543-0463).

8. Pregnancy Declared after Receiving more than 450 mrem

The State of Washington Radiation Protection Standards (WAC 246-221-055) contain the following provision:

> "If the worker has received more than 450 mrem during the time between conception and declaration of pregnancy, a 50 mrem dose limit applies to the duration of the pregnancy."

Since this 50 mrem secondary limit is very small, any declared pregnant worker who has already received more than 450 mrem during the pregnancy must seek immediate reassignment to duties which do not involve occupational radiation exposure.

Workers who are pregnant are encouraged to declare pregnancy even if their cumulative dose during the pregnancy has already exceeded 500 mrem. This will enable them to stay as close as possible to the 500 mrem limit.

9. Confidentiality

a. Declaration

Once a declaration of pregnancy is made, this information is retained as part of a worker's radiation dosimetry record.

b. Reports

Reports, showing an individual's monthly or quarterly radiation exposure, are normally distributed through the Area Dosimetry Coordinator for each area.

c. Privacy

If you wish to keep your pregnancy confidential, please contact the Radiation Safety Office at 206-543-0463. Otherwise, your fetal dosimeter will be mailed directly to the Area Dosimetry Coordinator who handles your regular dosimeter.

You are not required to disclose the declaration of pregnancy to anyone outside of the Radiation Safety Office. However, if your job duties or schedule must be modified in order to comply with the 500 mrem limit, then your department and your Human Resources representative must be included in this process.

10. Nondiscrimination

a. Pregnancy Discrimination Act

Employees who are pregnant are protected against job discrimination under the Pregnancy Discrimination Act and Title VII of the Civil Rights Act. You cannot be fired or penalized for declaring a pregnancy.

b. Potential for Childbearing

Additionally, an employer may not discriminate against any worker because of her potential for childbearing. There is no scientific or legal justification for restricting the duties or employment potential of nonpregnant radiation workers (ICRP 1990). Such discrimination is illegal.

11. Lead Aprons

a. Work Areas

Lead aprons are required for work with certain types of diagnostic x-ray equipment, being beneficial only in a few work environments where low energy x-rays are present.

b. Not Recommended to Protect Fetus

Unless you work in an environment where lead aprons are already required, a lead apron is not recommended as a means of protecting the fetus.

1) A lead apron is heavy and uncomfortable, especially during pregnancy,

and would usually add to fatigue. Also, the total amount of lead in an apron is limited by weight constraints and so lead aprons are not effective for many high-energy gamma-emitting radionuclides.

2) Your supervisor cannot require you to wear a lead apron unless it is already required for non-pregnant workers under state regulations.

12. Medical X-rays and Nuclear Medicine Procedures

a. Personal Medical Procedures

The occupational limits for declared pregnant workers do not apply to medical procedures when you are the patient. Your dosimeter(s) should not be worn if you receive medical diagnostic x-ray or nuclear medicine procedures.

b. Declaration Prior to Procedures

If you are pregnant and are scheduled for a diagnostic x-ray or nuclear medicine exam, you should tell the doctor and/or the technologist prior to the exam. In many cases, they may decide not to perform the examination. However, it is possible that the risk to the embryo/fetus from the radiation may be much smaller than the risk from allowing a medical condition to go untreated. You should discuss this with your doctor.

c. After Procedure

If you received a medical exam involving radiation while you were unaware that you were pregnant, you should discuss this with your doctor. In most cases, the doses are so low that there is no reason for concern.

d. Information on Risks from Exposure

If you or your doctor require additional information about risks from exposure to radiation or radiopharmaceuticals during pregnancy and lactation, you may contact Care Northwest. This service is provided through the University of Washington Medical Center and is not affiliated with the Radiation Safety Office. Care Northwest has a 900 number listed in the University of Washington directory. A small fee is involved.

D. Personnel Dosimeters

Personnel dosimeters are used for determining compliance with external occupational dose limits.

1. Types

a. Whole Body Dosimeters

1) Type of Measurement

A whole body dosimeter measures deep, lens and shallow dose equivalent from external radiation sources. The standard “whole body” badge is used primarily for gamma rays, x-rays and mid to high-energy beta radiation. A neutron detector can be incorporated, creating a dosimeter referred to as a "whole body plus neutron" badge.

2) Location of Use

The whole body badge is worn on the torso, at the chest or collar level. If a lead apron is used, the whole body (chest or collar) badge must be worn outside the lead apron. In rare instances, a second badge (waist badge) is also issued. When issued, the waist badge is worn under the lead apron.

3) Description

The type of whole body dosimeter currently in use is the “Luxel” optically stimulated luminescence dosimeter. This type of dosimeter consists of a thin aluminum oxide layer coated on a plastic base. Metal and plastic filters built into the dosimeter allow differentiation between different types and energies of radiation, enabling calculations of the radiation doses at several depths in tissue. “Luxel” dosimeters have a large dynamic range, excellent sensitivity, and long-term stability.

4) Detection Method

When energy is deposited in the material by radiation, the atoms of the material store some of the energy through excitation processes. Later the stored energy is “read” by cooling the dosimeter to very low temperatures, stimulating the material with laser light, and allowing the material to return to room temperature rapidly. The amount of luminescence produced by this process is proportional to the amount of radiation exposure the dosimeter received.

b. Extremity Dosimeters (Ring or Wrist Badges)

1) Reason for Use

In some cases, a radiation exposure involves a significantly greater dose to the hands than to the torso. In these instances, it is more important to monitor extremity dose than whole body dose. Ring badges are the primary mechanism for measuring extremity dose. Occasionally, it may be impractical or cumbersome to use a ring badge. In these instances, a worker may request issuance of a wrist badge (in lieu of a ring badge) to monitor extremity dose

2) Directions for Wearing Extremity Badges

The ring badge should be worn with the label facing the source of radiation on the hand likely to receive the highest dose. When high extremity doses are possible, ring badges may be issued for both hands.

The wrist badge consists of a Luxel dosimeter worn on a wristband. It is worn on the wrist likely to receive the highest dose.

3) Detection Method

A ring badge consists of a plastic ring containing a chip of thermoluminescent material (TLD). The TLD chip functions similarly to the optically stimulated luminescence detector described in the preceding section. When the dosimeter is "read," it is heated to approximately 300 degrees centigrade. The amount of light emitted by the TLD is proportional to the radiation dose.

c. Pocket or Self-Reading Dosimeters

1) Description

These dosimeters are roughly pocket sized and can be clipped to a belt or a pocket. Some of these units are air filled ion chambers, and others use a Geiger-Muller (G-M) counter. These instruments are usually only useful for measuring accumulated gamma or x-ray exposure, but they give immediate output. Self-reading dosimeters often have "chirping" alarms that inform the user after they accumulate a pre-set dose (like every 1/10 mR or 1 mR).

2) Conditions of Use

Self-reading dosimeters give immediate information about the work environment and are small enough to be worn like a whole-body dosimeter. They can be quite useful for evaluating which part of a procedure or experiment gives the highest dose to the operator. However, they provide an informal record of dose. In situations where whole body or ring dosimeters are mandated, a self-reading dosimeter does not replace the required whole body or extremity badges.

2. Working Conditions Requiring Personnel Dosimeters

a. Medicine

1) Nuclear Medicine and Radiotherapy

a) Personnel working directly with radiopharmaceuticals – *whole body and ring dosimeters.*

b) Individuals administering brachytherapy or handling brachytherapy sources - *whole body and ring dosimeters.*

c) Individuals providing care for patients who have source implants or radiopharmaceutical administrations greater than 20 millicurie – *whole body dosimeter.*

d) Individuals providing external beam radiation therapy using the cyclotron or linear accelerators – *whole body or whole body with neutron dosimeter.*

2) Diagnostic Medical X-ray

a) Individuals having frequent and direct association with patients during radiographic and/or fluoro exams:

- No likelihood of hands in direct fluoro beam – *whole body dosimeter.*

- Likelihood of hands in direct fluoro beam – *whole body and ring dosimeters.*

b) Multiple whole body dosimeters may be required by the Radiation Safety Office (collar and waist badges) during interventional radiology procedures where the worker could receive a significant fraction of the annual occupational dose limits.

3) Dental or Veterinary X-ray

a) Infrequent entry of the room during radiographs – *dosimeter not required.*

b) Routine entry of the room during x-ray operation:

- For a fixed-direction tube where procedures ensure sufficient distance from the x-ray unit to avoid potential exposures – *dosimeter not required.*

- For systems where individuals could remain near the x-ray but where there is no likelihood of direct beam exposure to the hands – *whole body dosimeter.*

- For individuals with a likelihood of direct beam exposure to the hands – *whole body and ring dosimeters.*

b. Research

1) Accelerators (Non-Hospital)

a) Nuclear Physics Laboratory – *whole body or whole body with neutron dosimeter (depending on whether a significant neutron component is present).*

b) Other Facilities – *no monitoring required unless the Radiation Safety Office determines that there is a potential for occupational exposure exceeding 10% of the annual dose limits. Whole body or whole body with neutron dosimeter may be required in some instances.*

2) X-ray Units (Non-medical use)

a) Analytical x-ray units with no accessible beam – *dosimeter not required.*

b) Analytical x-ray units with accessible beam – *ring dosimeter.*

3) Radioactive Materials (other than sealed sources)

a) Using exclusively low energy beta emitters (beta Emax < 0.5 MeV, no gamma or x-ray) – *dosimeter not required.*

Includes:

H-3	C-14	P-33	S-35

b) Using between 1 and 10 mCi of high-energy beta or beta-gamma emitters (beta Emax > 1 MeV regardless of gamma energy) – *ring dosimeter.*

Includes:

Na-24	P-32	K-40	K-42	Ca-47
Mn-56	Fe-59	Co-60	Y-90	Mo-99
Ag-110m	I-132	Cs-137	Au-198	Bi-213

Sr-90 (unless it is confirmed that the Y-90 daughter is absent)

c) Using between 1 and 10 mCi of any positron emitter – *ring dosimeter.*

Includes:

C-11	N-13	O-15	F-18
Co-58	Cu-64	Zn-65	

d) Using more than 10 mCi of any radionuclide (except pure beta emitters with beta Emax < 0.5 MeV) – *ring and whole body dosimeters.*

4) Sealed Source Use

a) Gamma, x-ray or beta sources that are completely shielded and enclosed during operation (no accessible beam) – *dosimeter not required.*

b) Gamma, x-ray or high energy beta (Emax>1 MeV) sources greater than 10 mCi source with accessible beams – *ring and whole body dosimeters.*

c) AmBe, PuBe or other neutron sources larger than 10 mCi – *whole body with neutron dosimeter.*

c. Declared Pregnant Occupational Workers

1) Declared pregnant workers who work in an environment with the potential to exceed 100 mrem per year deep dose equivalent.

2) Declared pregnant workers who are not monitored and believe they may exceed the above levels should contact the Radiation Safety Office.

3. Application for Dosimetry Service

Personnel dosimeters are provided to the University community through the Radiation Safety Office (RSO). To facilitate the distribution of dosimeters, each group using dosimeters is assigned a Series Code and has an appointed Area Dosimetry Coordinator.

a. Area Dosimetry Coordinator (ADC) Responsibilities

1) Submits dosimeter applications to the RSO.

2) Distributes and collects monthly dosimeters.

3) Requests change in service.

4) Receives monthly reports, making them available to dosimetry users.

5) Receives and distributes annual reports to individuals.

b. Setting up New Series Code

If a new group requires dosimeters, call the RSO (206-543-0463). If possible, we will handle the request through an existing group. If not, a new Series Code will be created.

c. Forms

1) Request for Radiation Worker Dosimeter – RSO Form 7

2) Request for Fetal Monitoring – RSO Form 9.

If confidentiality is preferred, call the RSO for a Form 9 instead of contacting the ADC. See part C of this Section, Declared Pregnant Worker.

4. Use of Luxel Dosimeters

a. Occupational Exposures

Wear dosimeters only to measure occupational exposures. Do not wear dosimeters when receiving medical or dental radiation exposure.

b. Positioning on the Body

1) Face the dosimeter away from the body, with the holder's clip toward the body.

2) Keep the front of the Luxel dosimeter clear of tapes or clips, as these items may interfere with the radiation exposure reading.

3) Unless it is a fetal monitor, wear the Luxel whole body dosimeter near the collar, in order to include radiation exposure to the lens of the eye.

4) Wear Luxel fetal monitors at the waist and under leaded protective aprons, if applicable.

c. Storage

1) Remove dosimeters from unworn aprons or lab coats stored in radiation areas.

2) When not using your dosimeter(s), store them in an office area away from environments where radiation exposure above background would be encountered.

d. Single Wearer

Do not share dosimeters among multiple workers. Call the Radiation Safety Office for individual badges.

5. Over Exposure Notifications

In addition to notifications to individual workers, the Radiation Safety Office is required to report doses exceeding the maximum permissible dose limits (listed under Part B of this section) to the State of Washington Department of Health, Division of Radiation Protection.

E. Bioassay and Internal Dosimetry

The University of Washington applies techniques suggested by the US NRC Regulatory Guides 8.9 and 8.20, NUREG/CR 4884, and Committee 2 of the International Commission on Radiological Protection (ICRP Report 30) as principle basis for internal dose calculation.

The radionuclides iodine (iodine-125 and iodine-131) and tritium (hydrogen-3) are of primary concern for internal dosimetry for various reasons. Radioiodines are among the most hazardous and most volatile radionuclides. Tritium is among the least hazardous, but is easily absorbed through the skin. An *in vivo* counting procedure provides a rather simple method for evaluation of the internal dose for iodine-125 and iodine-131, while an *in vitro* procedure for hydrogen-3 is used.

The internal dose from other radionuclides may occasionally require some level of evaluation following an accident. An ad hoc program will be established when needed.

1. Radioiodine

a. University of Washington Policy

Each person who works in a laboratory where more than 0.5 mCi of radioiodine (iodine-125 or iodine-131) is ordered or stored in a calendar quarter is included in the Radiation Safety Office in vivo thyroid bioassay program. This activity (0.5 mCi per calendar quarter) is a conservative adjustment of the recommendations of USNRC Regulatory Guide 8.20.

1) Calendar-Quarter Requirements

Since all radioiodinations at the UW must be performed in a fume hood, Regulatory Guide 8.20 indicates that bioassay would not be required for processes involving less than 10% of 10 mCi (1 mCi) over “any three month period.”

From an administrative standpoint, setting a lower activity limit of 0.5 mCi and determining need for and performing bioassay on a quarterly basis versus “any three month period” is much more practical. The bioassay program consists of at least one measurement per person each calendar quarter, taken several days after the radioiodine work.

2) Single Use Requirements

In addition to the calendar-quarter bioassay requirements, single use bioassay requirements have been established that are consistent with

Regulatory Guide 8.20. Each person who directly handles more than 1 mCi of radioiodine on any single occasion is required to have a thyroid bioassay measurement taken by the Radiation Safety Office staff within one week of the work.

For medical personnel administering radioiodine in capsule form, thyroid bioassays are not required (Regulatory Guide 8.20 and WAC 246-239-035).

b. Thyroid Measurement

The *in vivo* thyroid bioassays are made with an instrument that is calibrated for the thyroid measurements and has a sensitivity for detecting at least 5 nCi of iodine-125 and 1 nCi of iodine-131.

c. Measurement Exceeding 14 nCi

When a measurement indicates an individual has exceeded a thyroid burden of 14 nCi since the last measurement, the RS staff shall investigate the cause of the exposure. The activity, 14 nCi, indicates that potentially an intake of 10% of the Annual Limit on Intake for I-131 has occurred since the last bioassay. I-131 is the "worse case" radionuclide of iodine commonly used at the UW. Multiple bioassay measurements will be performed if the RS staff's investigation reveals the likelihood of an individual's intake being greater than 10% of the Annual Limit on Intake for the radionuclide(s) involved.

d. Dose Calculations

The thyroid dose calculation includes an extrapolation of inhaled or ingested activity or the time of a thyroid measurement back to the intake at the time of exposures. Standard dosimetry and retention information is used for dose calculations. However, biological information for the exposed individual should be substituted when available. The committed dose equivalent and a committed effective dose equivalent to the thyroid are determined and expressed in millirem.

e. Measurement Exceeding 40 rem

An individual who has a measurable thyroid burden which indicates a committed dose equivalent to the thyroid of more than 40 rem will be restricted for the remainder of the year from further work with radioiodine. The value of 40 rem was established to assure that the sum of the deep dose equivalent (from external exposure) and the committed dose equivalent to the thyroid do not exceed 50 rem.

A finding of a sum total of deep dose equivalent and committed dose equivalent to the thyroid for any calendar year of more than 50 rem is considered in excess of the limits of WAC-246-221-010 and will be reported to DOH in accordance with WAC-246-221-250 and 260.

f. Annual Report

The Radiation Safety Office will provide an annual report of internal dose records to every individual who has received a measurable dose during the annual period. An annual summary of employee dosimetry will also be provided to the RSC, including a comment on corrective action, if taken.

2. Tritium (H-3)

It is usually necessary to establish a bioassay program for the evaluation of possible internal dose when working with large amounts of tritium (H-3). An exception to this requirement is when H-3 is contained in any sealed source or when it is absorbed on metal foils in quantities less than two curies.

Authorization for more than 100 mCi of H-3 will normally be limited to work that can be done in a hood with a face velocity greater than 100 linear feet per minute. Proposed work that cannot meet this condition must be supported by a detailed description of alternative protection measures.

a. Specific Rules

Specific rules for bioassay of large amounts of unsealed/unattached tritium are defined as follows:

1) Anyone working with more than 100 millicurie (mCi) of H-3 in a single use must have a bioassay within one week of each single use.

2) Anyone working with a throughput of more than 100 mCi in a month must have a bioassay once a month.

b. Tritium Urine Analysis

Analysis of urine for tritium content has proven to be the most reliable method for determining the concentration of tritium in body water. In most cases, after H-3 enters the body, it will distribute into body water and will not concentrate. It is eliminated with a biological half-life of 10 to 15 days due to the normal turnover of body water. The internal dose can be calculated if the concentration in urine is determined. The results must be reported on Radiation Safety Office (RSO) Form 202.

1) Arrangements for urine bioassays are the responsibility of the Authorized Investigator (AUI) and can usually be done with resources available in the laboratory where tritium is used.

2) Urine samples should not be collected until after a complete voiding. This assures that any intake of tritium will have the opportunity to be equally distributed in all body fluids, including urine. Care must be taken to avoid contamination of the sample by contaminated hands. The

preferred sampling time is first thing in the morning following an exposure and before any other laboratory work. A sample must be taken within one week of exposure.

a) Gross Count

A simple gross count can be made by adding 1.0 milliliter (ml) of sample fluid to 15 ml of a water miscible liquid scintillation cocktail, e.g., Aquasol. Count the sample for 10 minutes and compare to a 10-minute background count. If the sample count minus background is less than MDC (see calculation D), the result can be reported as negligible and no further analysis is necessary. Results must be reported on RSO Form 202.

b) Controlled Analysis

Most laboratories routinely counting tritium with liquid scintillation methods have already established procedures that will allow an accurate analysis of tritium content in urine. These procedures are acceptable, provided that they are documented and include quality control of the background and counting standards. The procedures must be available for review by RS staff or Department of Health inspectors, if requested. In lieu of established procedures, the procedures for analysis of tritium in urine should be followed.

c. Tritium Bioassay using Internal Standard Method

Urine in a liquid scintillation cocktail sample will induce quench and result in reduced counting efficiency. The result is the inability to directly quantify the amount of tritium the sample contains. A simple way around this problem is through the use of an internal standard. This provides quench correction and a counting efficiency for your individual sample.

An uncontaminated (background) urine sample is processed in parallel with the actual (target) sample. The uncontaminated sample may be obtained from a co-worker or the individual being bioassayed prior to the tritium procedure. The uncontaminated sample is counted to determine the background count rate. The target sample is counted and background is subtracted to establish the net sample count rate. Subsequently, the target sample is "spiked" with a known quantity of tritium (internal standard), and then counted again to establish the added count rate corresponding to a known amount of tritium.

1) Definitions

bkg	=	background
cpm	=	counts per minute
dpm	=	disintegrations per minute
EFF	=	efficiency

MDA	=	minimum detectable activity
MDC	=	minimum detectable counts
ml	=	milliliter
std	=	standard
μCi	=	microcurie

2) Procedure

a) A counting standard containing a known amount of tritium must be prepared to provide an activity concentration of approximately 2000 dpm/ml. Enter exact dpm/ml in calculation (a.) of the following section.

b) A one-milliliter sample of non-contaminated (background) urine must be obtained.

c) A one-milliliter sample of unknown (target) urine to be analyzed must be obtained.

d) Prepare two scintillation vials. Introduce one milliliter of background urine to one of the vials. Introduce one milliliter of target urine to the other.

e) Add 15 milliliter of an appropriate scintillation cocktail to both vials and count both with a liquid scintillation counter (LSC). Convert the raw counts into count rates (cpm) by dividing by the counting time.

f) The net sample count rate equals the target sample count rate minus the background sample count rate. See Calculations (b.) in the section below.

g) One milliliter of standard tritium solution is then added to the target sample vial and again it is counted with a LSC. Convert this raw count into a count rate (cpm) by dividing by the counting time.

h) Subtract the count rate obtained when you first counted the target vial from the count rate you obtained after adding the standard solution. This value equals the net standard count rate (in cpm). See calculation (c.) in section below.

i) Since samples and standards were processed in one-milliliter quantities, count rates can be directly expressed in count rate concentrations (cpm/ml).

3) Calculations

a) $std \;=\; \_\_\_\_\_\_\_\_ \; dpm/ml$

b) $target\ sample\ (cpm) - bkg\ sample\ (cpm) =$
$net\ sample\ \_\_\_\_\_\_\_\_\_\ cpm/ml$

c) $target\ sample\ with\ std\ (cpm) - target\ sample\ (cpm) =$
$net\ std\ \_\_\_\_\_\_\_\_\_\_\ cpm/ml$

d) $$\frac{net\ std\ (cpm/ml)}{std\ (dpm/ml)} = EFF\ (cpm/dpm)$$

e) $$\frac{net\ sample\ (cpm/ml)}{EFF\ (cpm/dpm)} = sample\ activity\ (dpm/ml)$$

f) $$\frac{sample\ activity\ (dpm/ml)}{2.22\ x\ 10^{6}\ (dpm/\mu Ci)} = sample\ activity\ (\mu Ci/ml)$$

g) $$4.65\ x\ [bkg\ (cpm)/counting\ time\ (\mathrm{min})]^{1/2} = MDC\ (cpm)$$

h) $$\frac{MDC\ (cpm)}{EFF\ (cpm/dpm)\ x\ 2.22\ x\ 10^{6}\ (dpm/\mu Ci)} = MDA\ (\mu Ci/ml)$$

4) Sample Results

If greater than “0”, the results of these procedures must be documented on RSO Form 202. The Authorized Investigator should retain the white copy. Send the yellow copy to the Radiation Safety Office (RSO) at Box 354400 or hand carry it to the Radiation Safety Lab in HSB T556. The RSO's copy will be placed in the individual's dosimetry file and kept as part of their permanent record.

Results which indicate a concentration of more than 0.001 µCi/ml must be immediately reported to Radiation Safety (206-543-6328) and arrangements made to provide a urine sample for analysis by an outside organization.

F. Personnel Exposure Records

1. Monthly Reports

a. Processing

Dosimeters are due at the Radiation Safety Office by the 15th of each month. Upon receipt, the dosimetry service provider processes the dosimeters and then sends two copies of the monthly report to the RSO.

b. Report copies

1) The original copy of the monthly report is retained by the RSO.

2) The duplicate copy is sent to the Area Dosimetry Coordinator (ADC) for posting.

c. No Exposure Reading

"Absent" in column 5 of the report indicates an unreturned dosimeter. If the dosimeter is lost, report it to the RSO.

2. Annual Reports

All individuals assigned a dosimeter and/or had an internal radiation exposure (bioassay) greater than "0" will receive an annual report. In the spring, these reports are sent to the ADC for distribution to participants. Duplicate copies are kept by the RSO.

An individual may request information about their exposure history at any time by calling the RSO.

3. Request for Exposure History

There are situations where individual records of exposure history may be generated.

a. Individual Request

An individual may request a record of their exposure history. The individual's supervisor may also make this request for exposure history.

b. Former Worker Request

A subsequent employer, or a worker formerly employed at the UW may request a record of the worker's exposure history.

c. Terminating Worker Request

A worker who is terminating their employment at the UW may request a record of their personal exposure history. This record can be provided to the worker or the worker's designee. If the most recent individual monitoring results are not available at that time, a written estimate of the dose will be provided along with a disclaimer that this is only an estimate.

4. Notification of Concurrent Employment

a. State Regulations

Under State regulations, the University of Washington must ensure that worker doses are within the annual occupational limits. These annual limits apply regardless of whether the exposure is received solely at the University of Washington, or at some combination of UW along with other facilities. If an individual goes to work at another facility while still employed by the University of Washington, the UW retains the responsibility to track the combined occupational dose.

b. UW Radiation Worker's Responsibility

Any worker who is currently issued a dosimeter by the University of Washington must inform the Radiation Safety Office if another employer (concurrently) monitors their radiation exposure. This information must be provided in writing to the Radiation Safety Office and must include the name, address, and telephone number of the other employer as well as the dates of employment at the other facility. Such notification is only necessary when an individual concurrently receives dosimeters or bioassays at UW and non-UW facilities.

It is not required if the individual terminates employment at the University of Washington before working for the other facility or if the individual works at a job that does not require dosimeters or bioassays.

Section 7

ALARA Program

Contents

Tables

A. ALARA Principle

ALARA is an acronym formed from the phrase "As Low as Reasonably Achievable." The phrase refers to a principle of keeping radiation doses and releases of radioactive materials to the environment as low as can be achieved, based on technologic and economic considerations.

1. Biological Basis

The biological basis for radiation protection assumes a conservative estimate of radiation dose versus effect, termed the "linear hypothesis." This hypothesis asserts that any dose, no matter how small, may inflict some degree of detriment. This detriment takes the form of a postulated risk of cancer and genetic damage. These risks already exist in the absence of radiation, but could be increased by exposure to ionizing radiation. The University of Washington's Radiation Safety (RS) program, therefore, strives to lower doses. In nearly all situations this can be accomplished, but sometimes this involves more costly practices. Eventually, the costs outweigh the benefit of further dose reduction. ALARA serves as a balance in the University of Washington's radiation protection program.

2. Applied Practices

ALARA principles are commitments to safety by all parties involved in the use of radiation at the University of Washington and include a wide range of easily applied practices. Most of these practices are "common sense". The following paragraphs in this chapter address general ALARA philosophy. However, this entire manual specifically addresses user responsibilities and good practices consistent with both the ALARA program and requirements of the Washington Administrative Code.

3. Operational Dose Limits

A supplementary element to ALARA principles is a set of operational dose limits, called ALARA investigation levels, that should also be readily achievable using easily applied practices. The University of Washington's Radiation Safety program specifies ALARA investigation levels that are well below legal limits.

Investigation levels should not be confused with dose limits that must be strictly adhered to for meeting regulatory compliance. Instead, doses exceeding ALARA investigation levels should alert management, Radiation Safety staff, and radiation users that a review may be needed in an attempt to identify better practices.

4. Collective Dose

In addition to maintaining doses as low as is reasonably achievable for individuals, the sum of the doses received by all exposed individuals (collective dose) should also be at the lowest practicable level. It would not be desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional people and significantly increasing the sum of radiation doses received by all involved individuals.

B. Radiation Safety Committee Commitment to ALARA

1. Radiation Safety Committee Authority

The Radiation Safety Committee's (RSC) authority is essential to the enforcement of an ALARA program. The RSC or its designees will thoroughly review the qualifications of each applicant for radioactive materials use. This review will take into account the types and quantities of materials used, the user's training and experience, and methods of use for which application has been made. An authorization will only be approved if it seems apparent that the applicant will be able to take appropriate measures to maintain exposure ALARA.

2. Designated Authority

The RSC designates authority to the Radiation Safety Office (RSO) for enforcement of the ALARA concept, and will support the RSO when it is necessary for the RSO to assert authority. The RSO performs a review of occupational radiation exposure with particular attention to instances in which the investigation level is exceeded. The RSO reports this to the Radiation Safety Committee.

3. Annual Review

A formal review of the Radiation Safety program is performed annually by the Radiation Safety Committee (RSC) or their representative. This includes reviews of operating procedures, past dose records, inspections, etc., as well as consultations with Radiation Safety staff and others with a qualified interest in the UW Radiation Safety program. This review is reported to the University of Washington management through the Executive Director of Health Sciences Administration.

C. Radiation Safety Office Commitment to ALARA

1. Radiation Safety Officer

The Radiation Safety Officer enforces the ALARA program through management and technical supervision of Radiation Safety Office staff.

2. Radiation Safety Staff

It is the duty of the RS staff to contribute to the ALARA program through the following areas:

a. Implementation of ALARA Principles

Provide appropriate technical support and guidance to Authorized Investigators and their staff for implementing ALARA principles.

b. Facility Design

Provide input to facility design to comply with regulations and appropriate guidelines.

c. Audits and Surveys

Perform laboratory audits and supplemental RSO laboratory surveys.

d. Monitor Personnel Doses

Provide monitoring of personnel doses through bioassay and assignment of dosimeters when appropriate.

e. Review Occupational Exposures

Review occupational exposures with particular attention to exposures exceeding the ALARA investigation levels. The Radiation Safety Officer reports these instances to the Radiation Safety Committee.

f. Training/Consultation

Provide worker training or consultation.

D. Management Commitment to ALARA

Authorized Investigators and responsible individuals, in consultation with the Radiation Safety Office (RSO), should make sure that ALARA Principles have been considered and incorporated into processes, facilities, and experiments. This could include special monitoring or dosimetry requirements, training, and equipment.

Department managers are also encouraged to review current procedures and develop new ones as appropriate to implement the ALARA concept. These reviews and other routine assessments may suggest the need for modifications to current operating and maintenance procedures, equipment, and facilities. These modifications should be made if they reduce exposures unless the cost is considered to be unjustified (note section I).

E. Employee Responsibility

Employees are responsible for their own safety, specifically in the following areas:

1. Awareness

a. Hazards and Safety Controls

Become familiar with potential radiation-related hazards and safety controls in the areas in which they work.

b. Operating and Emergency Procedures

Become familiar with and follow the operating and emergency procedures pertaining to their assignments.

c. Radiation Levels

Be aware of the radiation levels associated with work assignments.

d. Consult with Supervisors

Consult with supervisors prior to beginning work where whole body or extremity dose could be significantly higher than previously encountered.

e. Inappropriate Practices

Discontinue any practice that does not appear to follow the ALARA principle.

2. Compliance

a. Accident/Incidents

Promptly report radiation accidents, incidents, and unsafe working conditions to supervisors and, if appropriate, also notify the Radiation Safety Office.

b. Dosimeters

Wear a personal radiation dosimeter if one is assigned and exchange it promptly as directed by the Radiation Safety Office.

c. Bioassay

Comply with bioassay requirements.

F. ALARA Principles for Mitigating External Radiation Hazards

The following mitigation methods can often be a practical and effective means of minimizing external radiation hazards. These methods are discussed in greater detail in Section 9 – Radiation Protection Procedures.

1. Time

Reduction of time of exposure can directly reduce radiation exposure.

2. Distance

Increasing the distance between you and the radiation source will reduce exposure by the square of the distance. This principle applies to sources of penetrating radiation (x-rays, gamma rays, or high-energy beta particles). Increasing distance may not be necessary if the radiation is non-penetrating (alpha particles or low energy beta particles).

3. Shielding

Shielding a radiation source often involves additional economic considerations. It is not necessary to shield every source. However, shielding can effectively reduce radiation doses in some situations.

G. ALARA Principles for Mitigating Internal Radiation Hazards

The following general principles are effective for mitigating internal radiation hazards. These are discussed in greater detail in Section 9 – Radiation Protection Procedures.

1. Good Hygiene

Good hygiene habits and good housekeeping effectively moderate the internal radiation hazards presented by radionuclides. Essential elements of good hygiene are eliminating food and drink in areas where radioactive materials are used and/or stored, and controlling “hand to mouth” habits.

2. Control of Contamination

Effective ways to heighten awareness and prevent the spread of contamination is to label radioactive (and potentially radioactive) areas and items, contain contamination, or decontaminate surfaces.

3. Airborne Hazards

Using fume hoods and avoiding dust, aerosol, or volatile gas production can reduce the potential for inhalation of radioactive substances.

4. Protective Clothing

The use of gloves, laboratory coats, and other protective clothing minimizes the chances for the ingestion or absorption of radioactive materials.

H. ALARA Exposure Investigation Levels

1. External Exposure

There are two ALARA investigation levels for external occupational radiation exposure as measured by personal dosimeters. Quarterly limits for each level are listed in Table 7-1. Dose categories with an asterisk (*) denote a higher limit for some workers as determined by the RSO.

Table 7-1 Quarterly ALARA Investigation Levels

Dose Category	ALARA Level I (mrem)	ALARA Level II (mrem)
Deep	125	375
Deep*	375	625
Lens	375	1125
Lens*	1125	1875
Shallow	1875	5625
Extremity	1250	3750

a. ALARA Level I

If a radiation worker exceeds this level of dose in any quarter, a health physicist will review the employee's dose history and work assignment to determine if any action is needed.

b. ALARA Level II

If a radiation worker exceeds this level of dose in any quarter, a health physicist will investigate and report findings to the Radiation Safety Committee. A written notification will be sent to the worker.

2. Internal Dose

a. Radioiodine

The ALARA investigation level for exposure to radioiodine is 14 nCi, which is equivalent to a dose of 10% of the Annual Limit on Intake (ALI) for I-131, or a Committed Dose Equivalent of 5 rad to the thyroid, assuming 45 days between intake and bioassay date.

b. Tritium

The ALARA investigation level for exposure to tritium (H-3) is 0.015 microcurie/ml in urine. This is approximately equivalent to a dose of 10% of the ALI for H-3, assuming 45 days between intake and bioassay date. Individual laboratories may choose to perform their own screening bioassays for tritium. However, samples must be submitted for a more rigorous analysis if the urine concentration exceeds 0.001 microcurie/ml (corresponding to less than 1% of the ALI).

I. Cost-Benefit Analysis in ALARA

The International Commission on Radiological Protection (ICRP) has issued a publication titled, "Cost Benefit Analysis in the Optimization of Radiation protection" (1983) – Publication 37. This reference serves as a framework for describing how cost-benefit considerations can play a major role in the decision-making process for optimizing radiation protection.

The basic principle behind cost-benefit methods is to select a protective measure that results in a net benefit that exceeds the next best alternative. The most common method of selecting a protective measure is to assign a dollar cost for a specific dose reduction. The range of costs that have been considered to balance the cost versus risk is normally $200 to $2500 per person-rem reduction in collective dose.

ICRP Publication 37 also gives examples that can be used as guides for evaluating protective measures or systems (such as shielding or ventilation) for particular facilities or experiments under consideration.

Section 8

Worker Rights and Responsibilities

Contents

Washington Administrative Code (WAC) 246-222 establishes requirements for notices, instruction, and reports by the University of Washington to individuals engaged in work with radiation. The Code further provides options available to such individuals in connection with State of Washington Department of Health (DOH) inspections. The regulations in Chapter 246-222 apply to all persons who receive, possess, use, own, or transfer a source of radiation licensed or registered by the University of Washington with the Department of Health.

A. Posting of Notices to Workers

1. Radiation Safety Office

Washington Administrative Code requires certain documents be available for inspection by individuals engaged in work with radiation. The documents listed below are available for inspection at the University of Washington, Radiation Safety Office, 205 Hall Health Center.

a. Regulations

The regulations in WAC Chapter 246-221 and Chapter 246-222.

b. License

The UW Radioactive Materials License WN-C001-1.

c. X-ray Registrations

UW x-ray registrations for Hall Health Center, Harborview Medical Center, Non-Human Use, Nuclear Physics Laboratory, Roosevelt Clinic, School of Dentistry, Sports Medicine Clinic, and University of Washington Medical Center.

d. Conditions/Amendments

Conditions or documents incorporated in the license by reference and amendments thereto.

e. Operating Procedures

Operating procedures applicable to work under the license or registrations.

f. Notices of Noncompliance

Any notice of noncompliance involving radiological working conditions, proposed imposition of civil penalty, order issued pursuant to Chapter 246-220 (General Provisions), or any response from the University of Washington.

2. Radiation Areas

The following documents, notices, and forms must be replaced if altered or defaced:

a. Emergency Procedures

Emergency Procedures must be conspicuously posted in areas where radiation workers will see them. These procedures should be posted in all areas where radioactive materials are used.

b. “Notice to Employees” (RHF-3)

Department of Health Form RHF-3 “Notice to Employees,” described in greater detail below, must also be conspicuously posted in all areas where radiation is used.

B. RHF-3 “Notice to Employees”

The Department of Health Form RHF-3, “Notice to Employees,” is posted in radiation use areas on campus and should be read by employees. This document gives a brief overview of worker’s rights and responsibilities. This includes a listing of required posted documentation noted in the previous section, a listing of what is covered by the regulations, worker’s rights to information about exposure history (if applicable), and worker’s rights to make inquiries or allegations to the DOH regarding suspected non-compliance.

C. Worker’s Responsibility

It is a radiation worker’s responsibility to protect themselves, co-workers, patients (if any), and the public from undue risks of radiation, to the extent of the worker’s control. This can be fostered by becoming familiar with radiation protection procedures in this manual, provisions of the Department of Health regulations, and the operating procedures, which apply to an individual’s work.

D. Instruction to Workers

WAC 246-222-030 lists specific instructions to be provided to individuals likely to receive an occupational dose. Although some workers may work in situations where they could not receive a measurable occupational dose, all radiation workers at the University of Washington should still be aware of these provisions of the Washington Administrative Code. Instruction in this information is usually accomplished through the Radiation Safety Training Class and job specific instruction from the Authorized Investigator or laboratory manager.

1. Storage, Transfer, Use

All Radiation workers shall be kept informed of the storage, transfer or use of sources of radiation in the Authorized Investigator’s facility. This is the responsibility of the Authorized Investigator or his/her designee.

2. Health Protection Considerations

Radiation workers shall be instructed in the health protection considerations for the worker and potential offspring associated with exposure to radiation or radioactive material, in precautions or procedures to minimize exposure, and in the purposes and function of protective devices.

3. Observance of Requirements

Radiation workers shall be instructed in and instructed to observe, to the extent within the worker's control, the applicable provisions of the DOH Regulations, DOH Form RHF-3 "Notice to Employees" and license conditions for the protection of personnel from exposures to radiation or radioactive material.

4. Notification to Department of Health

a. Violation Notification

A radiation worker shall be instructed that any worker or representative of workers who believes that a violation of the regulations, license conditions, or unnecessary exposure to radiation exists or occurred, may request an inspection by the Department of Health by oral or written notification. The notification shall set forth specific grounds for the complaint. Any such notification to the Department of Health is confidential.

b. Improper Actions

A radiation worker has the right to notify the Department of Health if the individual suspects improper actions by a licensee/registrant, or conditions, which may lead to a violation of these regulations, the license/registration, or unnecessary exposure to radiation or radioactive materials.

5. Discrimination

Radiation workers shall be instructed that employment discrimination by a licensee/registrant against an employee, because of actions described in WAC 246-222-030, is prohibited.

6. Notification to Supervisor and Radiation Safety Officer

Radiation workers shall be instructed as to their responsibility to report promptly to their supervisor any condition which may constitute, lead to, or cause a violation of Washington Administrative Code regulations and licenses or unnecessary exposure to radiation or radioactive material. If satisfactory response is not received from their supervisor, they may then contact the Radiation Safety Officer.

7. Unusual Occurrence/Malfunction

Radiation workers shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material.

8. Radiation Exposure Reports

Radiation workers shall be advised as to the radiation exposure reports which workers shall be furnished pursuant to WAC 246-222-040. These records and reports are discussed in the Radiation Safety Training class and in Section 6 of this manual, Personnel Exposure and Monitoring.

Section 9

Radiation Protection Procedures

Contents

A. Radiation Hazards

Irradiation of the body can happen via two processes, external or internal.

1. External Radiation

External irradiation results from radioactive material, radiation sources, or radiation producing machines. This radiation is produced external to the body and may or may not penetrate deep into the body, depending upon the radiation energy. The irradiation ceases as soon as the radiation source is removed. Some types of external radiation are not significant external hazards.

a. Alpha Emitters and H-3

Alpha particles from alpha emitting radionuclides and beta particles from H-3 (tritium) lack the ability to penetrate the outer layer of the skin and are not considered external radiation hazards.

b. Low-Energy Beta Particles

In addition, low-energy beta particles from C-14 and S-35 do not penetrate the skin significantly and are usually not considered an external hazard when used in typical laboratory quantities.

c. Gamma Emitters, X-rays, and High-Energy Beta Particles

Gamma rays, x-rays, and high-energy beta particles are the typical external radiation hazards.

2. Internal Radiation

Internal irradiation results from the ingestion, inhalation, injection, or absorption of radioactive materials into the body. The radioactive substances irradiate body tissues, and the irradiation continues until the radionuclide physically decays and/or it is biologically removed from the body. The degree of hazard depends upon several factors, including individual radionuclide, chemical form, and amount of activity ingested or inhaled.

a. Alpha and Beta Emitters

Alpha particles cause dense ionization and biological damage close to the point of origin. Alpha particles do not travel outside of the organ in which they are generated.

b. Beta Emitters

Beta emitters are less hazardous (internally) than alpha emitters but can provide significant doses to organs in which they may be concentrated (such as iodine concentrating in the thyroid).

c. Gamma Emitters

All alpha emitters and many beta emitters concurrently emit gamma rays. The gamma rays can deposit energy in surrounding tissues and organs. Some of the gammas may escape the body without depositing energy. Measurement of these escaping gamma rays can be an important means to quantify the activity of a gamma emitter remaining within the body.

d. Organs of Concentration

Internal radiation dosimetry is a complex subject with many variables. One of the complicating factors is that different radionuclides concentrate in different organs or areas of the body depending on the chemical nature of the radionuclide. For example, iodine concentrates in the thyroid, whether it is radioactive or not. This unequal distribution can cause the dose to adjacent organs to be widely different for the same intake.

B. Personal Protective Measures - External Radiation

1. Time

Reduction of exposure time can be used to minimize external radiation hazards through the following mechanisms:

a. Reduce Radionuclide Handling

Think of ways to modify or organize the experiment or procedure to reduce radionuclide handling.

b. “Dry Runs”

Practice “dry runs”, without using radionuclides, to improve the pace of laboratory procedures.

c. Planning

Do your thinking, writing, and conversing away from the radiation field.

2. Distance

Increasing the distance between you and the radiation source will reduce exposure by the square of the distance. Distance can be increased by the following practices.

a. Tools

Use tools with long handles for intense sources of penetrating radiation.

b. Separation from Radiation

1) Use stands and clamps to hold the radioactive material and place the radionuclide set up as far back from occupied areas as possible.

2) Step back or out of the area when not directly working with radiation sources.

3. Shielding

Shielding a radiation source can effectively reduce radiation exposure rate, providing the following cautions are observed. It is not always necessary to exactly calculate the shielding properties of a barrier you have erected; simply check out the attenuated beam with a survey instrument.

a. Edges of Shield

Be aware of the approximate size of the protective shadow of the shield and keep away from edges when practical.

b. Scatter Radiation

Remember that shielding effectiveness is lessened when scattered radiation is a significant factor.

c. Proximity to Source

Shielding is most effective when it is placed close to the source.

d. Shielding P-32

Plastic shielding (1/4 inch) is most effective for P-32 and other high-energy beta emitters since plastic reduces *bremsstrahlung* production.

e. Lead Shielding

Lead is an efficient shield for most gamma emitters. 1/16 inch of lead will shield the weak gamma photons from 1-125, but 1/2 inch to 1-inch lead is needed to reduce most gamma beams to 10% of their original intensity.

C. Personal Protective Measures - Internal Radiation

1. Good Hygiene

Good hygiene habits and good housekeeping effectively mitigate the internal radiation hazards presented by radionuclides. Part of good hygiene is control of mouth habits and eating.

a. Mouth Habits

Anything brought to your mouth while working in a lab could result in ingestion of contaminants. Avoid habits such as fingernail biting, chewing on pens, pencils or other objects. Do not lick stamps or envelopes while in the lab. As always, never pipette by mouth of hold laboratory supplies in your mouth.

b. Food, Drinks, and Smoking

Food (including gum), drinks and smoking are forbidden in labs. *Remember that:*

1) Somebody's lunch, drink, or snacks may become contaminated with radioactive material and the end result could be accidental ingestion.

2) Preparation of food or drink in a lab is forbidden. There is always a risk of incorporating radionuclides into the food or beverage.

3) Eat, drink, and/or smoke only in a clean area away from the laboratory.

4) Do not use laboratory paper or glass containers for food or drink containers. These containers may have residual radionuclide contamination, or an individual may accidentally ingest a radioactive preparation thinking it is a foodstuff stored in a similar container.

5) Do not store food in refrigerators containing radioactive materials. Signage is available to post refrigerators for "No Food or Drink" or "Only Food and Drink." See Section 10 – Area Classification and Posting.

6) Before leaving the laboratory, wash your hands and leave your lab coat and gloves behind, along with any radioactive material they may have collected.

2. Surveys

Identification and control of contamination is one of the primary methods of avoiding internal radiation dose. Proper survey procedures are described in Section 13 – Laboratory Survey Procedures.

a. Self Contamination and Laboratory Surveys

The most essential and often most overlooked problem in coping with a contamination incident is recognizing that the incident has occurred. Frequent surveys of oneself and the areas or items in proximity to the use of radioactive materials are one of the most useful methods of discovering contamination. These surveys do not need to be documented, but should become a matter of habit to a radiation worker.

b. Laboratory Equipment Surveys

Lab procedures utilizing centrifuging, shaking, or freeze-drying techniques may produce aerosols, gases, powders or dusts. Spills or breaks are also a possibility. Each time these types of procedures are performed and special equipment is used with radioactive material, contamination should be suspected and appropriate surveys should be done of the equipment and adjacent areas.

c. Common Use Equipment Surveys

A radiation worker must always be aware of the need to survey for contamination of commonly used items and equipment like light switches, door handles, sink faucets, computers, and telephones. Often, data entry, telephone calls, and other distractions occur during procedures, and this can lead to contamination spreading beyond the laboratory setup. Commonly used items have the greatest potential to pass contamination to several individuals.

d. Survey before Leaving

A radiation worker should always survey oneself before leaving the area after participating in radiation work. Radiation surveys should always be conducted before leaving an experimental setup unattended, and before allowing potentially contaminated items or equipment to be used by others.

3. Decontamination or Control of Contamination

When contamination does occur, the area of contamination should be limited or contained by isolation. Verbal notifications, warning signs, and labels should be used to alert others to the presence of the hazard until subsequent cleanup activities are completed. Decontamination is the responsibility of the individual causing the spill, but call for assistance if deemed necessary or if you are inexperienced in decontamination efforts. Radiation Safety (RS) staff is available to provide assistance in decontamination, if necessary. See Section 1 – Emergency Procedures for information regarding decontamination procedures.

4. Airborne Hazards

Initial control of airborne radionuclide contamination is accomplished by:

a. Recognition

Initial control of airborne radionuclide contamination is accomplished by evaluating procedures, material, and equipment that may result in the production of aerosols, volatile gases, or dusts.

b. Preventative Steps

After these opportunities for airborne hazards are identified, precautions must be taken to assure there is minimal chance for exposure to personnel. Examples of precautions would include performing the procedure in a fume hood or enclosing the process in suitable containment.

5. Personal Protective Equipment

The use of gloves, laboratory coats and other protective clothing minimizes the chances for the ingestion or absorption of radioactive materials. In rare situations, the use of suitable respirators might be recommended to prevent the inhalation of volatile or airborne radionuclides.

a. Gloves

No unsealed radioactive materials should be manipulated with the unprotected hand. Latex or nitrile gloves are the most common types used in research laboratories at the UW, but several other types of gloves are available from safety supply vendors. The choice of glove type for work with radioactive materials should be based on the carrier material. For example, latex would be satisfactory for work with water based solutions, but nitrile would be necessary when working with toluene based scintillation fluids.

Following are some proper glove procedures:

1) Clean Hand

It is sometimes possible to use just one hand for "dirty" work and keep the other hand (held behind the back) free of contamination for clean work (hot hand cold hand technique). The clean hand is then available for touching common-use items like computer entry, recording data, and answering the telephone,

2) Sleeves and Cuffs

Tape up sleeves and cuffs to keep them from dragging on potentially contaminated surfaces.

3) Good Glove Practice

A gloved hand with contamination on the glove will spread contamination to clean areas and although the individual remains uncontaminated, his fellow workers are exposed to contamination. If there is potential for contamination of a glove, it must be removed or surveyed before handling common-use items.

4) Glove Removal

Gloves should be removed by turning them inside out. Grasp the outside surface and strip the glove off inside out. Never insert gloved fingers inside the top of the glove to assist in removal. The fingers of the clean hand can be inserted inside the second glove for removal. Do not blow into glove to return it to its original form for re-use or to check for leaks. This practice allows opportunity for ingestion of material from a contaminated glove.

5) Double Gloves for Radioiodine

Wearing a double layer of gloves is required when doing radioiodinations, and recommended whenever doing other work with radioiodine (e.g., I-125, I-131). Double gloving protects from radioiodine's tendency to permeate some types of glove materials and also provides some skin protection from beta particles and electrons.

6) Impromptu gloves

Plastic wrap can sometimes be used as impromptu gloves or protective clothing in an emergency. Avoid this for routine use.

b. Lab Coats

Laboratory coats or aprons are recommended to protect one's personal clothing from contamination. Coats or aprons worn as protective clothing should remain behind in the laboratory at the end of the day or whenever the individual leaves the laboratory. It is particularly important not to wear lab coats that may be contaminated with radioactive materials into eating areas, such as cafeterias.

c. Respirators

The use of respirators for protection from airborne radionuclide hazards is not a preferred option at the University of Washington. In nearly all situations where significant airborne radioactive materials are involved, a fume hood or hot-cell is the preferred control measure. On rare occasions, respirators have been used at the University in particularly dusty operations involving radioactive materials, such as removing air filters from particle accelerator exhaust ducts.

The Environmental Health and Safety Department has specific requirements for individuals using respirators. For further information, please refer to this specific information on the EH&S website:

https://www.ehs.washington.edu/workplace/respiratory-protection.

Call the Radiation Safety Office (RSO) if the need for a respirator is anticipated when performing a particular operation or experiment.

d. Protective Eyewear

Protective eyewear (safety glasses) is recommended whenever using unsealed radioactive or hazardous materials. This eyewear must be kept clean and replaced if scratched, or the visual field can be affected.

e. Open Sores/Wounds

Open sores or wounds on exposed body surfaces provide an opportunity for absorption of radioactive materials. It is best to avoid work with radioactive materials, or properly dress and protect open sores or wounds before working with radioactive materials.

D. Personal Protective Measures - General

1. Planning Work

All radioactive material work should be carried out according to some prearranged plan. Any departure from the plan should incorporate a reassessment of the radiation hazards involved.

2. Knowledge of Radionuclides Being Used

To prepare laboratory personnel to deal with unusual occurrences, the chemical and physical properties of the radionuclides in the laboratory should be common knowledge to all individuals working in the laboratory.

3. Training and Experience

Lack of training and experience can contribute to an accident or hamper one's ability to mitigate an accident. If you do not feel you have the proper training or experience for using radioactive materials, inform your supervisor. Your supervisor must provide training specific to the tasks you perform and commensurate with the risk you are exposed to. Generic training in radiation safety is provided in the Radiation Safety Training Course offered by the UW Radiation Safety Office. See Section 5 – Training Requirements.

4. Fatigue and/or Emotional Factors

Fatigue and/or emotional factors can contribute to a radiation incident. Be sure you are "clear-headed" when performing work with radioactive materials or any hazardous material.

5. Responsibility and Motivation

Individuals using radioactive or hazardous materials must realize their responsibility for safe use of these materials. It is also necessary to be positively motivated toward safety to adequately protect oneself and one's co-workers.

6. Corrective Eyewear

Individuals must wear appropriate corrective eyewear to properly visualize their work. Sometimes, individuals choose to forego use of corrective lenses when using safety glasses, but this is an unsafe course of action. Preferred alternatives for individuals needing corrective eyewear would be to wear contact lenses under safety glasses, use corrective safety glasses, or use safety glasses specially designed to fit corrective eyewear.

7. Environmental Factors

a. Proper Lighting

Proper illumination is necessary to visualize the tasks that one is doing. This can be particularly problematic when using a fume-hood with poor illumination or a dirty sash. Keep hood sashes clean, replace burned-out lighting, and use supplemental lighting if necessary.

b. Proper Temperature

Temperatures less than 60° Fahrenheit (F) reduce dexterity and control, while temperatures greater than 75° F foster deterioration of coordination.

c. Cluttered Working Conditions

Crowded, cluttered, or contorted experimental setups promote fatigue and irritability and can foster an accident. Re-configure or clean up your workspace, if necessary.

E. Radiation Area Control Procedures

The following radiation safety procedures and practices protect the radiation worker, co-workers, and the general public.

1. Authorizing Radionuclide Use

All areas, rooms, or laboratories in which radioactive materials are to be used or stored, must be certified as radioactive materials usage areas, and must be added to an Authorization to Use Radioactive Materials. See Chapter 4 – Authorization

Process.

2. Security

Security of radioactive materials, radiation sources, or radiation producing machines protects the user from liability, and the unauthorized user or the public from radiation exposure.

a. Prevent Relocation, Loss, or Theft

Radioactive material, including that in animals, patients, and equipment/sealed sources, should be prevented from leaving designated controlled areas under circumstances that may subject other persons to unnecessary exposure to radiation. One of the key responsibilities of the Authorized Investigator (AUI) is the security against theft of radioactive materials, and unauthorized use of radiation sources or radiation producing machines. When the radionuclide laboratory is to be left unoccupied by responsible laboratory personnel, it should be locked.

b. Secure Storage

Stock solutions (undiluted radioactive materials as supplied by the manufacturer) are required to be locked in their place of storage when not in direct use and in view of the researcher. This is generally a refrigerator, freezer, or cabinet. If you have radioactive stock solutions but do not have a way to lock them, contact the UW Radiation Safety Office (206-543-6328) for consultation. Locks and other devices are available through this office for reduced cost.

Care must be taken to secure all radioactive materials (not just stock solutions) from laboratory visitors, custodians, and individuals with malicious intent. This would be diluted radioactive materials, materials being used in an experiment, and radioactive waste. Security is generally accomplished by securing/locking your laboratory or storage area when you are not in direct attendance. Treat your radioactive materials as you would any other valuables in your workspace (purses, computers, etc.). Also, challenge individuals you do not know who enter your workplace, even if they appear as workers or inspectors wearing a uniform or carrying a clipboard. Radioactive materials which generate an external radiation hazard must also have adequate shielding to protect individuals frequenting the vicinity of the storage area.

c. Report of Suspected Loss or Theft

Suspected loss or theft of radioactive material must be reported immediately to the RSO. An investigation may include a follow-up inspection by the State of Washington Department of Health.

3. Appropriate Signs and Labeling

Appropriate radiation warning signs or labels must be used to designate radiation areas and to identify radioactive material containers or rooms containing radioactive materials. During the setup of a new laboratory, RS staff usually post or provide appropriate signage, but the AUI is responsible for maintaining that posting. Requirements for the types and locations of these signs or labels are provided in Section 10 - Area Classification and Posting.

a. Label Radioactive Material Containers

Clearly label all containers of radioactive materials. This includes containers of working solutions, stock solutions, and waste. Custodians occasionally mistakenly collect radioactive waste. A very apparent sign should be attached to each waste container to indicate radioactive waste and forestall accidental pickup by the custodial service. Use the standard radiation sign or a strip of “radioactive” labeled tape.

b. Obliterate Labels when No Longer Applicable

Standard radioactive waste packages or boxes should be used only for radioactive material. Containers that once contained radioactive material should have labels or signs removed or marked out before the container is discarded or empty containers are placed in storage. The labels are intended as a warning. When a warning is not necessary, there is a false concern, or worse, a future disregard for the proper warning. When these empty containers appear in public areas or in normal trash, they cause unnecessary alarm. It is also illegal to intentionally use radiation warning labels on non-radioactive items.

c. Penalties for Non-Defaced Labels

Custodians are alerted against picking up containers with an intact radiation symbol. However as noted above, containers with radiation markings are occasionally mistakenly picked-up by custodians. UW containers that no longer contain radioactive materials yet still had intact labels have been found in off-site transfer stations operated by Seattle’s disposal contractor. The alarm raised by these incidents has resulted in warnings to the UW and the threat of penalty charges or refusal to accept waste.

4. Records

Proper records are necessary for documenting protection of radiation users and the general public, as well as being required for compliance with radiation protection regulations, and conditions of authorization.

a. Radiation Use Records (RSO Form 160)

Records of the use of radioactive materials must be kept. A tally of the disposition of radioactive materials should be made on the back of the RSO Form 160, which accompanies any delivery of radioactive material. After the order of radioactive materials has been accounted for, the completed Form 160 must be returned to the Radiation Safety Office for computer record entry. You should keep a copy of the Form 160 for three years after the material is completely disposed. See Section 11 - Procurement of Radioactive Material for a further description of the use of RSO Form 160.

b. Radioactive Waste Disposal Records (RSO Forms 150 and 170)

1) Boxes, Pails, or LSC Fluid

Records of the disposal of radioactive materials into boxes, pails, or in liquid scintillation (LSC) fluid should be recorded on RSO Form 150 or its equivalent. When the package of waste is ready for transfer to the Radiation Safety Office, totals from the Form 150 must be included with the package. The Form 150 should remain in laboratory records.

2) Sewer

Disposal of soluble or dispersible radioactive materials into the sink must be recorded on RSO Form 170 or its equivalent. See Section 14 - Radioactive Waste for more information on waste collection, packaging, and recording.

c. Survey Records

Records of radiation surveys must be kept in the laboratory for examination by RS staff and DOH inspectors. See Section 13 - Laboratory Survey Procedures for information regarding requirements for performing and recording laboratory surveys.

d. Calibration Records

Records on the calibration of radiation detection instruments should be kept in the laboratory for reference. The UW Radiation Safety calibration staff also attaches calibration records to the side of the instrument.

e. Records of Unusual Occurrences

Records of unusual occurrences such as incidents and accidents should be recorded for future reference. Incidents reported to the RSO are kept in office files, but the laboratory is encouraged to keep their own records. These records may be useful if a DOH investigation occurs at a later date.

f. Records Retention

Records noted above generally need to be kept for at least three years. Records of unusual occurrences may need to be kept longer at the discretion of the Authorized Investigator.

5. Reportable Incidents

To protect radiation workers and the general public, certain situations must be reported to the UW Radiation Safety Office, and may need to be further reported to the State of Washington DOH on an immediate basis. Contact the RSO immediately to make an initial investigation in the event of suspected lost, stolen, or missing radioactive material; suspected excessive radiation exposure of an individual; or suspected release of excessive quantities of radionuclides to the environment.

6. Organizational Plan for Radiation Protection

Organization of procedures and practices in the laboratory should be accomplished in advance of the actual start of laboratory operations. Prior to issuing an authorization, policies and procedures are reviewed between Radiation Office staff and new investigators. This is also an opportunity to discuss any questions regarding radiation safety matters.

a. Responsibilities and Duties

Good radiation safety practice depends on an effective health and safety organizational plan. Responsibilities and duties must be clearly assigned to assure safety and comply with authorization requirements and regulations. RS staff will discuss organizational issues with investigators prior to issuing an Authorization to Use Radioactive Materials.

b. Emergency Procedures

An emergency procedure plan should be in writing and readily available to all of the laboratory personnel. The plan should be discussed with all personnel so that each individual is aware of his/her role in the event of an emergency. Such a plan should include the emergency procedures included in the Authorized Investigator's application and authorization. Emergency procedures must be posted in all areas where radioactive materials are used. See Section 1 - Emergency Procedures and Section 10 - Area Classifications and Posting.

1) Special Hazards

In addition to general radiological control and decontamination procedures, emergency procedures should address the special hazards peculiar to the operations in the laboratory (i.e. associated chemical or biological hazards, unusually large activities, or special equipment).

2) Laboratory Radiation Safety Agent

The plan for major emergencies shall list the Authorized Investigator and the Laboratory Radiation Safety Agent (an individual designated to be in charge of directing emergency procedures) and both of their home or other emergency phone numbers (cell). For on campus emergencies, dial 9-911. For off campus emergencies, call University Police at (206) 543-9331.

7. Radionuclide Use in Animals

The Animal Care Committee in the Department of Comparative Medicine controls the use of animals in research studies at the UW. Animals may be housed in a research laboratory for up to 24 hours. If procedures will take a longer period of time, animals must be held in facilities approved by the Animal Care Committee.

a. Certified Radioactive Materials Space

If research involves the use of radioactive materials in animals, either approved animal care space or the researchers own space must be certified for radioactive materials use by the Radiation Safety Office. A RSO Form 50 must be filled out for the space and submitted to the RSO. Space may be assigned either for a short period of time, “short-term use”, or for a longer period of time. Please indicate on the Form 50 the estimated length of time that the room will be used.

b. Posting

All cages or pens containing animals with radioactive materials must be labeled with appropriate warning signs. The Radiation Safety Office will advise the Authorized Investigator of the appropriate signage. Similar to other rooms where radioactive materials are used, animal rooms must be posted with appropriate signs, emergency procedures, survey requirements, and certification documents. These signs and postings will be provided during certification of the space by RS staff. In certain situations where animals have been injected with very short-lived radionuclides and need to be held for a short period of time, posting of the temporary holding space with appropriate signage will be the responsibility of the investigator.

c. Monitoring/Calculation

Monitor or calculate the activity levels and the activity per gram of animal carcasses, bedding, and waste materials as they are produced. These activity levels will be necessary to determine proper methods or disposal.

d. Waste Disposal

Methods for the appropriate disposal of animal carcasses, contaminated animal waste, and bedding are described in Section 14 - Radioactive Waste.

8. Termination or Inactivation of Radionuclide Use

a. Termination

Authorized Investigators who will be leaving the University of Washington or who will be retiring and no longer maintaining an active research program should arrange for termination of their authorization.

b. Inactivation

Authorized Investigators who do not have a current need to use radioactive materials in their research programs, and who do not expect such need to arise for an extended period of time, should arrange for inactivation of their authorizations.

c. Termination/Inactivation Requirements

Both termination and inactivation require that the entire inventory of radioactive materials be disposed and properly accounted for, all radioactive waste be removed from the laboratory, and all equipment that was used for radioactive materials work be properly and completed decontaminated.

The AUI should work with the Radiation Safety Office to determine that all paperwork has been completed, and all correct procedures have been followed. Once the Authorized Investigator is certain that all areas are free from contamination and materials, the Radiation Safety Office should be informed that the AUI's lab(s) are ready for inactivation/termination surveys.

9. Hospital Use of Radiation

The use of radionuclides at the University of Washington Medical Center and Harborview Medical Center are also covered under the UW Radioactive Materials License of Broad Scope. The specific hospital use of radiation differs in many ways from the general use of radiation covered under this manual. Therefore, hospital radiation use is covered under separate policies and procedures.

F. Laboratory and Equipment Requirements

The majority of research laboratories where radioactive material is used can be classified as chemical laboratories. Chemical laboratory setup is generally adequate for the small quantities of radioactive materials involved in most situations. However, some additional thought and preparation are recommended for work with radioactive materials.

1. Laboratory Layout

Radiation work should be consolidated both in respect to the area allotted to handling radioactive materials and to the amount of time spent in handling this material. Limiting the area expedites survey and decontamination procedures. Limiting the time spent in handling the radionuclides minimizes external radiation exposure and decreases opportunities for accidents.

a. Radiation Workspace

Layout of a laboratory where radioactive materials (RAM) are used should include assigning special places for the handling of these materials. These areas should be marked clearly. They should be located, as much as possible, away from the regular traffic patterns in the laboratory. In laying out the RAM work area, the possibility of accidental spills and the spread of contamination to adjacent areas and equipment should be kept in mind.

b. Storage Areas

Storage of the radioactive material should be such that the transfer route of the radionuclide to the working area is over as short a distance as possible. However, crowded areas should be avoided for the transfer route.

c. Waste Disposal Areas

Waste disposal containers should be close to the working area.

d. Record Keeping Areas

Record keeping of radionuclide use and disposal should be comprehensive and easily accomplished during the work or waste disposal processes without a disruption of the workflow or unnecessary trips to files located elsewhere in the laboratory.

2. Laboratory Requirements

The following are minimum facility requirements for use of radioactive materials. For certain types and uses of radioactive materials, however, additional facility requirements must be met. The specific requirements, which will vary from one situation to another, are determined at the time of authorization by RS staff.

a. Floors

Floors should be smooth, nonporous, easily cleaned surfaces. Appropriate floor materials include vinyl, tile and sealed concrete.

b. Benches

Benches must have nonporous, easily decontaminated surfaces. Surfaces of high quality plastic laminate or stainless steel are preferable.

c. Sinks

Sinks should be stainless steel or seamless molded construction. The sink designated for radioactive waste disposal should be clearly marked and should be located in the general area designated for radionuclide work. Forms for recording increments of radioactive waste disposal should be right beside the sink to encourage accurate record keeping of this type of disposal.

d. Hoods

1) Hood Not Required

Use of liquid radioactive material in a room without a fume hood is permitted if the ventilating rate is such that a spill and total volatilization would result in less than 10% of an annual limit on intake (ALI). If the radionuclide is in a nonvolatile form, the amount used can be greater. Using these criteria, a fume hood is seldom required for most procedures involving unsealed liquid radioactive materials at the UW, except for evaporations, radioiodinations (sodium iodide labeling reagent), and H-3 (tritium) labeling (in quantities greater than 8 mCi).

2) Hood Required

Radioiodinations, evaporations, high level tritium labeling, use of gaseous materials, or work with liquid radionuclides in amounts greater than those stated above must be done in a fume hood. Note that very small quantities of volatile radioiodine (5 μCi) can result in 10% of an ALI, whereas much greater quantities of volatile H-3 (8 mCi) could result in 10% of an ALI.

3) Hood Certification

Fume hoods must be currently certified. Hood airflow is checked with a calibrated instrument on an annual basis by personnel from the Environmental Health and Safety (EH&S) Department. In between annual checks, the airflow should be monitored with strips of paper or ribbons attached to the bottom of the sash.

4) Hood Flow and Construction

Hoods should preferably be constructed of stainless steel or molded fiberglass, and produce a regular flow of air of at least 100 linear feet per minute. Higher velocities are acceptable if no turbulence is generated. The speed of the airflow should be such that there can be no escape of air into the working place from the fume hood under typical operating conditions, including opening of windows and/or doors. The suction of other fume hoods or eddies caused by individuals moving quickly across the face of the hood must also be taken into consideration. This can be checked by smoke tests.

5) Hood Sink Traps

Because they dry out, hood sink traps should be checked periodically.

6) Hood Clutter

The hood should be kept free of clutter and large objects should be located to the rear of the hood to minimize the formation of eddy currents. Keep radioactive materials at least 6 inches inside the sash to avoid spilling it out through the sash of the hood.

7) Sash Height

The hood sash should be kept clean and lowered as far as practical to maintain appropriate face velocity. When in use, the sash should not be raised above the line on the hood frame demarcating 100 linear feet per minute.

e. Structural shielding

The need for structural shielding shall be evaluated when appropriate. For example, in facilities where large quantities of radionuclides emitting penetrating radiations are used, shielding in walls, floors, and ceilings may be required. Specific requirements for special shielding will be determined on a case by case basis by RS staff.

3. Equipment Requirements

Laboratories in which radioactive materials are to be used must have the following basic equipment and supplies:

a. Absorbent Paper and Spill Trays

Manipulations should be carried out over a suitable drip tray or with some form of double container, which will minimize the effects of container breakage or spills. It is also useful to cover the working surfaces with absorbent material to soak up minor spills.

b. Portable Radiation Survey Meter

A portable radiation survey meter is necessary for performing contamination surveys, although this is not required for laboratories in which only carbon-14, sulphur-35, or hydrogen-3 is used. Proper working order of the meter must be verified by checking the response against a stock solution of radioactive materials, or a “check source”. The instrument must also be calibrated at least yearly. The UW Radiation Safety Office maintains a calibration facility that is comparable in price to other facilities. An advantage of the UW facility for on-campus users is quick turn-around time and avoidance of shipping/handling fees.

c. Access to a Liquid Scintillation Counter

Use of a liquid scintillation counter is necessary for analyzing wipes from contamination surveys when meter surveys alone are not adequate. Examples would be when carbon-14, sulfur-35, or hydrogen-3 (tritium) is used. See Section 13 - Laboratory Survey Procedures. Calibration of the liquid scintillation counter for detection of the radionuclide of interest must be also assured.

d. Portable Beta Shield

A portable plastic shield (Plexiglas® or Lexan® of at least ¼ inch) is recommended for laboratories in which high-energy beta emitters are used, such as P-32. This is particularly important when the quantities of P-32 being used exceed 10 mCi.

e. Waste Containers

Appropriate containers are necessary for solid and liquid radioactive waste. See Section 14 - Handling Radioactive Waste.

f. Personal Protective Apparel

Laboratory personnel must have access to appropriate protective apparel, such as lab coats and disposable gloves.

g. Radioactive Material Warning Tape

Radioactive material warning tape must be available for marking contaminated areas or equipment.

h. Appropriate Absorbent Materials and Cleaning Supplies

Appropriate absorbent materials and cleaning supplies must be available for spill control and decontamination.

Section 10

Area Classification and Posting

Contents

Warning signs and labels for Radioactive Materials and Radiation Areas are an important part of a successful radiation safety program. Proper posting promotes safe storage, use, and disposal of radioactive materials, as well as worker safety. All signs and labels should be obvious to anyone approaching the container or area, and easily read without risk to the observer. All postings using the conventional three-blade radiation symbol are required to have the symbol colored magenta, purple, or black on a yellow background. The following is a list of required postings, as well as where and when they are appropriate.

A. "Notice to Employees, DOH Form RHF-3"

Department of Health (DOH) Form RHF-3, "Notice to Employees" must be posted wherever individuals work or frequent and there is a likelihood of a radiation hazard. This includes radiation hazards from either radiation producing machines or radioactive materials.

STATE OF WASHINGTON
NOTICE TO EMPLOYEES

Employer University of Washington

Radioactive Materials License Number(s) WN- C001-1

X-Ray Registration Numbers: 03641 to 03647

THE SEAL OF THE STATE OF WASHINGTON 1889

In the Radiation Control Regulations, the Department of Health has established Standards for your Protection against Radiation Hazards

YOUR EMPLOYER'S RESPONSIBILITY:

Your employer is required to:

1. Apply these regulations to work involving sources of radiation.
2. Post or otherwise make available to you a copy of the Department of Health regulations, licenses and operating procedures which apply to work you are engaged in, and explain their provisions to you. These documents may be found and examined at: 201 Hall Health Center, University of Washington, Seattle, WA.
3. Post each Notice of Noncompliance involving radiological working conditions, proposed imposition of civil penalties and orders. These types of documents may be examined at: Same location as listed above.
4. Provide adequate radiation safety training to you, including training in the use and handling of radiation producing devices, as appropriate.

YOUR RESPONSIBILITY AS A WORKER:

You should familiarize yourself with those provisions of the Department of Health regulations, and the operating procedures which apply to the work you are engaged in. You should observe their provisions for your own protection and protection of your co-workers, patients (if any) and the public.

WHAT IS COVERED BY THESE REGULATIONS?

1. Limits on exposure to radiation and radioactive material in restricted and unrestricted areas;
2. Measures to be taken after accidental exposure;
3. Personnel monitoring, surveys and equipment;
4. Caution signs, labels, and safety interlock equipment;
5. Exposure records and reports;
6. Options for workers regarding Department inspections;
7. Performance standards for x-ray equipment; and
8. Other related matters.

YOUR RADIATION EXPOSURE HISTORY:

1. Your employer must advise you annually of your exposure to radiation.
2. If you receive an exposure in excess of any applicable limits, your employer must give you a written report within 30 days of learning of the overexposure. The basic limits for exposures to employees are set forth in WAC 246-221-010, 246-221-050, and 246-221-055 of the regulations.
3. Upon termination of your employment, you may ask for a written report of your exposure during the current year up to the date of termination. This may be an estimate as long as it is identified as such.

INSPECTIONS:

All licensed or registered activities are subject to inspection by the Department of Health or its duly authorized representatives. In addition, any worker or representative of workers who believes that there is noncompliance with Chapter 70.98 RCW, the regulations issued thereunder, or the terms of the employer's license or registration with regard to radiological working conditions in which the worker is engaged, may request an inspection by sending a notice of the alleged noncompliance to the Department of Health. The request must set forth the specific grounds for the notice, and must be signed by the worker or the representative of the workers. During inspections, Department inspectors may confer in private with workers, and any worker may bring to the attention of the inspectors any past or present condition which he or she believes contributed to or caused any noncompliance as described above.

INQUIRES:

Inquiries dealing with radioactive materials may be directed to the Department of Health, Radiation Protection, P.O. Box 47827, Olympia, Washington 98504-7827, Telephone (360) 753-4481. Inquiries dealing with radiation producing machines and facilities may be directed to the Department of Health, Radiation Protection, 1511 3rd Avenue, Melbourne Tower Bldg - 7th Floor, Seattle, WA 98101; Telephone (206) 464-6840.

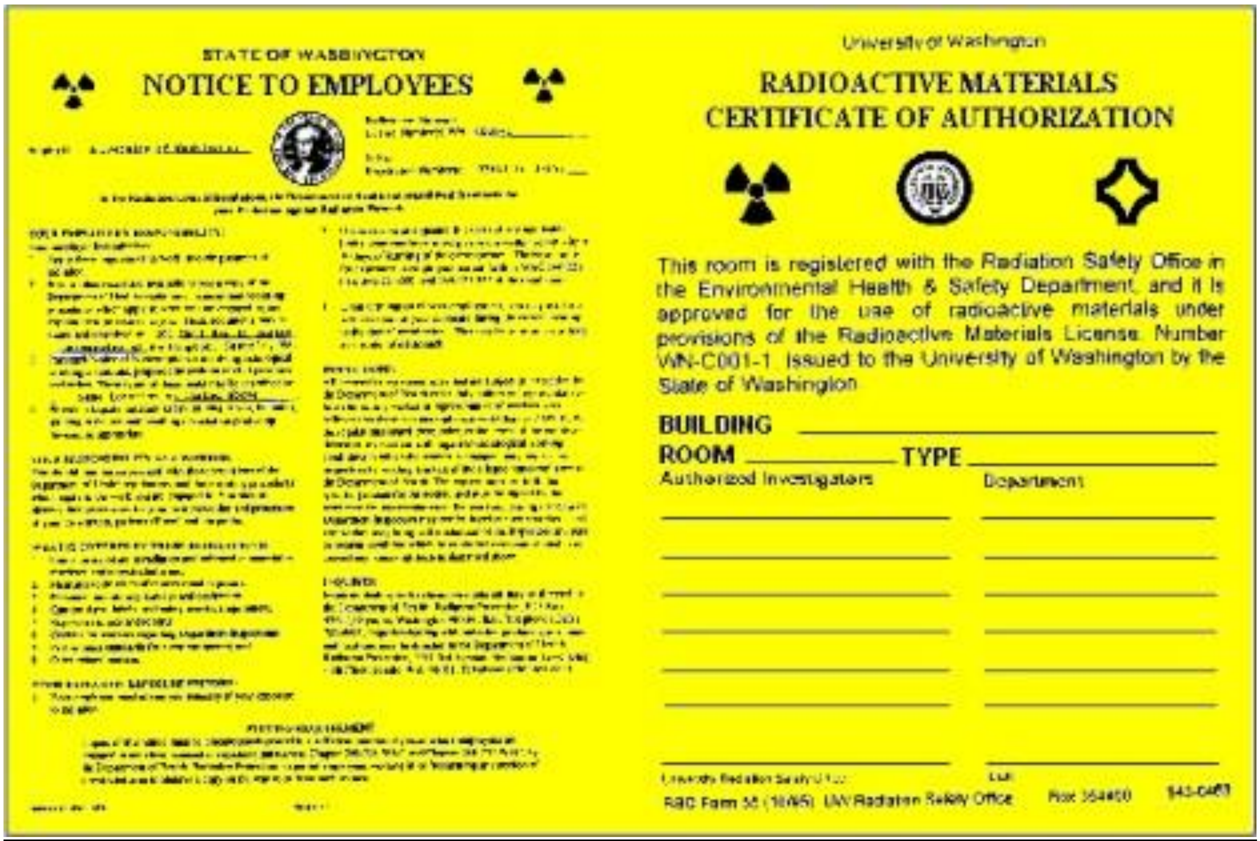
POSTING REQUIREMENT

Copies of this notice must be conspicuously posted in a sufficient number of places where employees are engaged in activities licensed or registered pursuant to Chapter 246-224 WAC and Chapter 246-235 WAC, by the Department of Health, Radiation Protection, to permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from such an area.

DOH 321-011 (Rev. 11/93) "RHF-3"

B. "Certificate of Authorization"

A sign (RSO Form 55) bearing the words "Radioactive Materials Certificate of Authorization" must be posted in any room authorized by the Radiation Safety Office for the storage or use of radioactive materials. The information on this Certificate is typically filled-in by Radiation Safety Office staff. This Certificate is usually printed on the same sign as the "Notice to Employees", DOH Form RHF-3.



C. "Emergency Procedures"

Pertinent emergency procedures must be posted in areas where radiation may be encountered, and as required by the State of Washington Department of Health. Laboratories at the University of Washington where radioactive materials are used have a standard posting. RSO Form 38 is used for laboratories off the main UW campus and RSO Form 39 is used for laboratories on the main campus. These forms must be filled-in with emergency contact names and telephone numbers. Specific user generated emergency procedures must be created for radiation producing machines.

EMERGENCY PROCEDURES

RSO Form 38 (12/96)

MUST BE POSTED IN EACH CERTIFIED LABORATORY IN A CONSPICUOUS LOCATION

Emergency Phone Numbers: ***(Fill in)***

Radiation Safety Officer **543-0463**
After hours, call University Police **543-9331**
Ask them to call EH&S Duty Officer. Give them your name and number.
Someone will call you back.

Authorized Investigator (Name & Home Phone) ____________________
Lab's Radiation Safety Agent (Name & Home Phone) ____________________

Radionuclides in Use: ***(Circle radionuclides being used in lab)*** (ALI = Annual Limit on Intake)

GROUP I ALI > 10 mCi	GROUP II 1 mCi < ALI ≤ 10 mCi			GROUP III 0.1 mCi < ALI ≤ 1 mCi		GROUP IV 0.01 < ALI ≤ 0.1 mCi
H-3	C-14	Mn-54	Mo-99	Na-22	Sr-89	Sr-90
F-18	Na-24	Fe-55	In-111	P-32	Cd-109	I-125
Cr-51	P-33	Co-57	I-123	Cl-36	Ag-110m	I-131
Cu-64	S-35	Co-58	Hg-197	Ca-47	Cd-115m	
Tc-99m	K-42	Ga-67	Au-198	Fe-59	Ir-192	

MAJOR SPILLS: ***Group I > 10 mCi / Group II > 1 mCi / Group III > .1 mCi / Group IV > .01 mCi***

1. **CLEAR THE AREA.** Notify all persons not involved in the spill to vacate the room.
2. **PREVENT THE SPREAD.** Cover the spill with absorbent pads or diatomaceous earth, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spre...
3. S... URCE. If nece... should be shi... only if it ca... ithout

D. "Caution, Radioactive Materials" (sign or label)

1. Where Posted

a. Room or Area

Any space in which radioactive materials or radiation sources are used or stored. These areas include, but are not limited to, laboratories, cold rooms, counting rooms, animal rooms, refrigerators/freezers, cabinets, and hoods.

b. Container

Any vessel, open or closed, in which radioactive materials are used or stored.

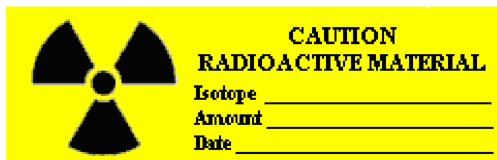
2. When Used

This sign should be used at all times, except for:

- ***Rooms or Areas*** in which containers will be attended and in which the containers will remain for short duration.
- ***Rooms or Areas in hospitals*** that are occupied by patients administered radiopharmaceuticals or permanent implants containing radioactive material, if the total effective dose equivalent to any other individual is not likely to exceed 0.1 rem (1 mSv).
- ***Containers*** that are in transport, and are packaged and labeled in accordance with the regulations of the Department of Transportation.

E. "Caution, Radioactive Material" (tape)

All ***contaminated and/or hot areas and items*** must always be labeled as radioactive, unless decontaminated to the background level.



F. Refrigerators or Freezers

Food and beverage intended for human consumption must not be stored in refrigerators or freezers used for the storage of radioactive materials. Laboratory refrigerators, ice chests, and cold rooms are not allowed for food or beverage storage

G. "Caution, Radiation Area" (sign or label)

A permanent sign bearing the words "Caution, Radiation Area" must be conspicuously posted in any area 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 cm from the radiation source or from any surface that the radiation penetrates***.

H. “Caution, High Radiation Area” (sign or label)

A permanent sign bearing the words “Caution, High Radiation Area” must be conspicuously posted in any area 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 cm from the radiation source or from any surface that the radiation penetrates***.

I. “Grave Danger, Very High Radiation Area” (sign or label)

A permanent sign bearing the words “Grave Danger, Very High Radiation Area” must be conspicuously posted in any area accessible to individuals, in which radiation levels could result in an individual receiving an ***absorbed dose in excess of 500 rads (5 Gy) in 1 hour at 1 meter from a radiation source or from any surface that the radiation penetrates***.

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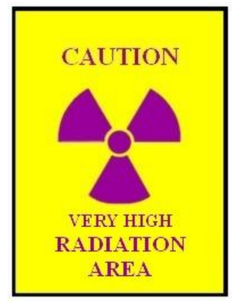

J. “Caution, Airborne Radioactivity Area” or “Danger, Airborne Radioactivity Area” (sign or label)

A permanent sign with the words “Caution, Airborne Radioactivity Area” or “Danger, Airborne Radioactivity Area” must be conspicuously posted in any room, enclosure, or operating area in which radioactive materials exist in concentrations:

- In excess of the derived air concentrations (DAC) specified in WAC 246-221-290, Appendix A.
- To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

<u>References:</u>

- Washington Administrative Code (WAC 246-220, 221, 240)
- Code of Federal Regulations part 20 (10 CFR 20.1003, 20.1902, 20.1904)

Section 11

Procurement of Radioactive Materials

Contents

A. Authorization to Order Radioactive Materials

All individuals wishing to purchase radioactive materials at the University of Washington must first have authorization to possess such material in the type and quantity requested. The authorization for possession and use of radioactive materials is issued through Radiation Safety (see Section 4 of this manual: Authorization Process). Specific radionuclides and activity limits are indicated in the authorization.

B. Orders

Orders for radioactive materials are made through the Ariba Spend Management System. Radioactive materials must be listed as *exception items* and must contain an object code of 0532 (Radioactive Chemicals). In most cases, orders for radioactive materials must be shipped to the Radiation Safety Shipping and Receiving Office in the Health Sciences Building, Room T274. Orders shipped to other locations require prior approval by Radiation Safety.

C. Approval of Radionuclide Order

All radioactive material orders entered in the Ariba Spend Management System are sent to Radiation Safety for review and approval before being sent to the vendor. Radiation Safety grants approval primarily based on a comparison of the PI's current inventory to the allowed limits on his/her authorization.

D. Radioactive Materials Inventory

The University of Washington maintains an inventory of all radioactive material on campus. The running inventory is updated when researchers either order new material or submit a Radioactive Material Usage and Disposal Record (Form 160).

1. Allowed Limits

An allowed limit of radioactive material is the amount a PI is allowed to have in his/her possession at any one time. Allowed limits are listed on a PI's authorization.

2. Amount On-Hand

The amount on-hand is specific to each nuclide and indicates the activity the PI has in his/her possession for that material.

3. Approved Orders

"Approved" orders are radioactive material orders that have been sent to the vendor, but have not been delivered to the University yet. Approved orders are added to the amount on-hand on the authorization, and reduce the activity that a PI may order.

4. Orders Arrival

All radioactive material shipped to the UW must be sent to the Radiation Safety Shipping and Receiving Office, room T274. Before Radiation Safety staff deliver material to the appropriate laboratory, the packages are checked for damage, contamination, and exposure rates.

5. Delivered Orders

A Radioactive Material Usage and Disposal Record (Form 160) is attached to every delivered order. At the top of the form, identifying information is listed to verify that the correct order was received. Check this form upon receipt. Call Radiation Safety (206-543-0463) if the information on the Form 160 is incorrect or if the wrong package was delivered.

6. Radioactive Material Usage and Disposal Record (Form 160)

The Radioactive Material Usage and Disposal Record (Form 160) is used to remove items from the PI's inventory by recording the disposal pathway. The PI or Laboratory Contact must fill out this form and return it to Radiation Safety. This decreases the amount on-hand for that radionuclide.

a. Total Disposal

Unless otherwise indicated, RS staff assumes that a returned Form 160 is a total accounting for the disposition of the original activity in the order. If the amount disposed does not equal the delivered activity, the lab will be contacted to resolve the discrepancy.

b. Partial Disposal

It is possible to report a partial disposal of a radionuclide, which can be used to decrease the amount on-hand. This must be indicated at the bottom of the Form 160. Partial disposals are only used in special circumstances and require prior approval by Radiation Safety.

c. Transfer

It is possible to transfer radioactive material to another PI or institution. However, Radiation Safety must be contacted before any material is transferred. Regulations require that the individual and/or organization receiving the material must be legally authorized to possess this material and that Radiation Safety has documentation of this authorization.

1) Transfer Form

A Radioactive Material Transfer and Usage Record (Form 160T), must accompany the radionuclide being transferred a PI at UW. A Form 160T is not required when transferring material to another institution.

E. Inventory Reports

The UW radioactive materials license requires that the radioactive material inventory be updated continuously. Therefore, Principal Investigators (PIs) are responsible for tracking and accounting for radioactive material used under their authorization. Radiation Safety (RS) will assist the PIs in maintaining their inventory by distributing inventory verification reports (IVRs) at regular intervals and issuing a Radioactive Material Usage and Disposal Record (Form 160) for all new radioactive material purchased under the PIs authorization. It is essential that the IVRs and Forms 160 are returned in a timely manner allowing the UW radioactive material inventory to be kept up to date.

1. Radionuclide Inventory Verification Report (IVR)

Twice per year, Radiation Safety (RS) will send each Principal Investigator (PI) a report of their current radionuclide inventory. The PI or Laboratory Contact is required to verify that the information provided on the report is accurate and then return the report to Radiation Safety. Changes can be indicated directly on the report.

The return of the Inventory Verification Report (IVR) is necessary to meet the conditions of the UW radioactive materials license, and therefore the return of the IVR will be strictly enforced. A PI will be allowed 30 days to return the IVR to RS, after which the following actions will be taken for non-compliance:

- Orders for new radioactive material will not be approved by Radiation Safety until the IVR is submitted.
- The PI will be contacted by the Radiation Safety Officer (RSO) to determine the status of the delinquent report.
- Further non-compliance will be reported to the Radiation Safety Committee (RSC) with additional notification to the PI's department head and/or dean as necessary. The RSC may also decide to place a restriction on the PI's authorization to use radioactive material as deemed necessary to ensure compliance.

2. Other Inventory Reports

At any time, a lab can request a current inventory report, or any other reports or information about the authorization.

Section 12

Shipment of Radioactive Materials

Contents

A. Shipping Regulations

The Nuclear Regulatory Commission (NRC), the Department of Transportation (DOT), and the Washington Department of Health (DOH) issue domestic regulations for the safe transportation of radioactive materials. These regulations are adopted from those issued by the International Atomic Energy Agency (IAEA). The Federal Aviation Administration (FAA) also has regulations governing the transportation of hazardous materials, radioactive materials, and biohazards as air cargo.

B. Shipment

All shipments of radioactive material will be performed by or with the direct oversight of Radiation Safety (RS). Radiation Safety must be notified prior to any shipment of radioactive material, either on or off campus. This ensures that all radioactive material is transported in accordance with all applicable regulations.

Occasionally RS will instruct a laboratory in the proper procedures for “empty,” “limited quantity,” or “instruments and articles” shipments of radioactive materials, which are made on a regular basis and are similar in nature. These shipments must always be approved by RS in writing.

1. Legal Authorization

Before shipping radioactive materials, the University of Washington must obtain written documentation that the recipients have legal authorization to have this material and activity in their possession. Normally, this documentation is a radioactive materials license.

2. Packaging

Radioactive materials must be shipped in properly authorized containers and be checked for contamination and external radiation levels prior to shipment.

3. Shipping Documents

All commercial shipments of radioactive materials must be accompanied by proper shipping documents.

4. Fines

Improper shipment of radioactive materials can lead to severe fines against individuals and organizations as well as the potential suspension or termination of a Radiation Use Authorization.

C. Portable Devices Containing Sealed Sources

Radiation Safety must be informed at least one month prior to the transportation of portable devices (such as gas chromatograph devices containing radioactive electron capture detectors) to off campus locations. This notification must include the location to which the device will be moved and the duration of time it will remain at that location.

RS will notify the WA DOH and request reciprocity to use these devices at locations where the UW Radioactive Materials License does not apply. RS will either perform the shipment or provide required training and procedures for transportation of the devices.

All portable devices must be in secured locations and are subject to periodic testing and inventory (see Section 15 - Sealed Sources).

D. Transport within the University System

To protect the university community, Radiation Safety adheres to all regulations to the extent deemed appropriate for any campus transfer of radioactive materials.

1. Hand Carried Transport

When transporting radioactive materials between rooms or buildings on campus, precautions must be taken to minimize the risk of accidents and the risk of exposing the public to radiation. A secondary container with enough absorbent material to retain the radioactive materials is required to minimize spills in the event of breakage or leakage of the primary container. The secondary container must be labeled “Caution: Radioactive Materials” along with the radionuclide and activity, and should provide adequate shielding if necessary.

2. Vehicular Transport

According to UW policy, radioactive materials must never be transported by public conveyance or via the campus shuttle. In special approved situations, private or University owned vehicles may be used for the transport of radioactive materials. Contact RS for assistance with transport of radioactive materials by vehicle.

E. Requesting a Radioactive Material Shipment

A Radioactive Material Shipment Request web form must be submitted to RS at least 72 hours or 3 business days prior to the date of domestic shipments. The request form is located at the following link: RAM Shipment Request.

International shipments require additional time and resources to notify all regulatory authorities, apply for special permits, obtain licenses and permits, and complete all required documentation including international customs documents. Therefore requests to ship radioactive material to international destinations must be submitted to RS at least one month prior to the date of shipment.

Section 13

Laboratory Survey Procedures

Contents

Tables

A. Purpose of Surveys

Frequent surveys are required in areas where unwanted contamination or external radiation fields may exist. Surveys with no evidence of contamination indicate good laboratory work practices. Good practices cannot be assured without these survey results.

It is difficult to define a "safe" or "allowable" level of contamination or external radiation. The important word is unwanted. If radiation is unwanted, efforts should be made to reduce it or eliminate it completely. Otherwise, it poses an unnecessary risk, however small. Beyond the safety issue, contamination or external radiation can interfere with experimental sensitivity and results.

It is the responsibility of the Principle Investigator (PI) and his/her laboratory personnel to assure that radioactive material is contained after each use and to perform appropriate surveys.

B. Survey Frequency

1. During Use Surveys and Self-Monitoring

Frequent surveys should be performed while working with radioactive materials. Self-monitoring must be performed before leaving the area. During use and self-monitoring surveys are not required to be documented.

2. After Use Surveys – Work Area(s)

An after use survey must be performed soon after each use of radioactive materials. The after use survey does not need to include the entire laboratory, but may be limited to the particular portion of the laboratory where the work took place. After use surveys do not need to be recorded unless specified in the PI's Radioactive Materials Use Authorization (RMUA).

3. Monthly Surveys – Entire Laboratory

A survey of the entire laboratory must be performed and documented each month. The surveys must be performed with instruments or wipes capable of detecting all authorized radioactive materials.

If radioactive material was not used during the month, a survey of the space is not required. However, the following (or similar) statement must be entered on the laboratory survey log each month; "No radioactive material use – No survey required."

4. Radioactive Material Storage Areas

All areas where unsealed radioactive material is stored must be surveyed each month. The survey must be documented and available for review by Radiation Safety. This survey is required regardless of the use of radioactive material in the room where the unsealed radioactive material is stored.

5. Common Use Area Surveys

When more than one authorized group uses a lab or space, the responsibility for performing monthly surveys may be shared. Each group is responsible for performing their own surveys during and after using radioactive material, but the monthly survey only needs to be performed once. Someone should be assigned to perform the monthly survey of the entire lab for all groups to ensure compliance. In common use areas, it is especially important to communicate to everyone involved when contamination is found.

6. Radiation Safety Surveys

Radiation Safety staff perform contamination surveys to satisfy Department of Health requirements for administrative oversight. These surveys are conducted on a monthly, quarterly, or annual basis.

C. Survey Methods

In general, surveys can be carried out in one of three ways. The preferred method depends on the radionuclides being used and the background level in the lab at the time of the survey. Below are more detailed explanations of the three methods.

1. Method 1 - Wipes / Scintillation Counting

The most significant radiation hazard in most laboratories is the potential ingestion or inhalation of transferable radioactive materials, rather than from external exposure. Ingestion or inhalation results in internal dose.

The main method for evaluating the ability for contamination to be transferred is to take a series of wipes from surfaces with small filter paper disks or squares of tissue and then evaluate the wipes with an appropriate detector. Wipes may be taken and counted in a counting device appropriate for the radionuclide(s) expected to be present.

Many investigators find it convenient to take wipes of their work areas immediately after preparing their research samples and running these wipes along with their samples. This gives immediate verification of the cleanliness of the lab and does not require an additional time allotment for lab survey measurements.

a. Choice of Counting System

The same counting system that is used in the experimental work will usually serve to evaluate the wipes, for example, liquid scintillation counting or gamma counting.

1) Liquid Scintillation Counting (LSC)

Low energy beta particles, like those emitted by H-3, C-14, and S-35, have a very short range and detection can be difficult. Liquid scintillation counting has an advantage in this situation since the wipe is mixed intimately with the fluids of the liquid scintillation cocktail. Radiation does not need to travel far to interact with the scintillation media and radiation interactions with extraneous material are reduced to a minimum. Therefore, radiation with short range is detected with reasonable efficiency. LSC also works with higher energy beta emitters as well as alpha and gamma emitters. However, as the energy of gamma rays increases, detection efficiency diminishes.

2) Gamma Counting

Gamma counting is most convenient for detecting the presence of gamma emitters on wipes. The detector in a gamma counter is usually a sodium-iodide crystal, but a semiconductor detector system (such as a germanium-lithium detector) can also be suitable for measuring wipe counts of gamma emitters. Gamma counters are also often used to check wipes for the presence of positron emitters by detecting the annihilation radiation.

b. Wipes

The typical wipe survey method utilizes dry filter papers being wiped over potentially contaminated surfaces, and then counting these filter papers in a liquid scintillation counter (LSC) or gamma counter.

1) Performing Wipes

The papers are wiped over a surface using moderate finger pressure so that about 100 cm^2 of surface is covered on each wipe. The wipes should be held so that your fingers will not touch the surfaces being wiped

2) Large Area Wipes

Certain surfaces (hood-lip, bench area, floor in front of work area, etc.) could be checked using just one wipe per surface. The advantage of this method is that results are obtained without counting multiple samples. The drawbacks are the potential to spread contamination and subsequent identification of the exact spot of the contamination.

3) Wipes near Radioactive Work

When wiping near radioactive work where contamination is expected, use extra care to avoid contaminating your hands and thereby cross-contaminating subsequent wipes.

c. Liquid Scintillation Counter (LSC)

1) LSC Wipes

a) The most convenient wipes for Liquid Scintillation Counting are filter papers, with a 4 to 5 cm diameter.

b) The papers should be dry when placed into the LSC fluid, or counting efficiency in the LSC will be greatly reduced.

2) Processing

a) Each wipe would then be put into a vial and scintillation cocktail added.

b) Sufficient cocktail should be added to completely wet the wipe. In a large 20 ml vial, at least 10 ml of cocktail should be used.

c) To check for background, you should run a clean wipe with each set of survey wipes.

d) All wipes should be counted twice.

d. Results

1) Wipe results greater than twice the background may indicate that there is a problem with containment in your laboratory and the situation should be investigated.

2) Levels of contamination greater than 0.5 nCi on a wipe must be reported on the survey form and action taken to clean the area(s).

e. Resurvey after Cleanup

To ensure that cleanup was successful, the area must be resurveyed and the results reported on the survey form. If radioactive materials have spread beyond controlled areas, the control procedures should be questioned and reviewed to prevent further contamination.

2. Method 2 - Portable Detector

For some radionuclides, discussed in more detail below, surveys may be done without taking wipes by using a hand-held detector. This is only feasible if the background level in the lab is sufficiently low.

If the background in the lab is more than three times the natural background, the sensitivity of the detector is reduced and low levels of contamination will not be detected. In this case, Method 1 or 3 should be used. To check for natural background, measure the radiation level using your particular instrument in some location that is certain to not be contaminated or influenced by nearby radiation sources.

When working with radionuclides that may be detected with portable instruments, it is extremely important to monitor your hands, clothing, and work areas while doing the work.

a. Sensitivity of Instrument

Your instrument should be sensitive enough to detect the following radiation levels. See Table 1 for a list of radionuclides classified into Hazard Groups.

1) For Group I radionuclides, 10 nCi at a distance of 1 cm from the surface.

2) For Group II radionuclides, 1 nCi at a distance of 1 cm from the surface.

3) For Group III and above radionuclides, 0.1 nCi at a distance of 1 cm from the surface.

b. Calibration

Your instrument must be calibrated annually. The UW Radiation Safety Office operates an instrument calibration facility. Costs of meter calibration at the UW facility are comparable to other calibration facilities. Advantages of using the UW calibration facility are shortened turn-around time and avoidance of shipping charges for on-campus users.

c. Operation

When using a hand-held detector, do the following:

1) Check battery.

2) Remove the protective plastic or metal cap from your probe.

3) Make sure instrument responds to a check source. This can be a commercial check source, stock solution, or other source the detector is known to respond to when properly working.

4) Check background in known low background area.

5) Survey within 2 or 3 cm of surfaces. If contamination is suspected, measure the level with the probe within 1 cm of the surface.

6) Go slowly so your detector has time to respond to contamination.

7) To guard against contamination of your probe, you could cover the probe with plastic wrap.

d. Results and Follow-Up

If instrument readings indicate contamination at more than 500 cpm above background, the contaminated areas or items should be cleaned, labeled, or disposed and the area resurveyed.

3. Method 3 - Portable Detector with Wipes

Even when a hand-held detector is available for survey purposes, there may be situations where wipes must be taken.

a. Background Level Too High

When the background level in a laboratory is too high (more than three times the natural background level as discussed in Method 2 above) wipes must be taken as described in Method 1 above. However, these wipes may be counted with the hand-held detector in an area with low background.

b. After Cleaning of Contamination Areas

Another situation where wipes must be taken would occur after some contaminated areas have been thoroughly cleaned and radiation levels are still observed with the hand-held detector. In this situation, wipes must be taken and counted to verify that the remaining contamination is not removable and would not be transferable to other areas.

c. Performing the Count

1) Screening Wipes

Counting each wipe for 10 seconds is usually long enough to obtain a consistent response and determine whether contamination is present.

2) Counting Contaminated Wipes

If contaminated wipes are suspected, count them for at least 30 seconds each to document the contamination level; and if the instrument has a fast/slow response setting, it should be set to "slow" for this purpose.

Action required when contamination is found is the same as discussed in Method 2.

d. Results and Follow-Up

If instrument readings indicate contamination at more than 500 cpm above background, the contaminated areas or items should be cleaned, labeled, or disposed and the area resurveyed.

D. Method for Specific Radionuclides

1. Hydrogen-3

Hydrogen-3 emits a very low energy beta radiation that will not penetrate the walls of most portable instrument probes. It must be surveyed by using Method 1 as described above.

2. Carbon-14 and Sulfur-35

Both Carbon-14 and Sulfur-35 are very low energy beta emitters and are not easily detected using a portable survey instrument. Therefore, the preferred method for surveying laboratories where these radionuclides are used is with wipes counted in a liquid scintillation counter.

However, in situations where a liquid scintillation counter is not readily available, either an end-window or pancake probe Geiger-Mueller counter could be used. The efficiency is low, but a slow, deliberate survey, with the probe held near the surface, can detect C-14 and S-35 in amounts of 0.5 nanocurie or less. This level of detection can be achieved when the count rate is twice background. This also is the level that must be reported on the survey form, and action must then be taken to clean the area.

3. Iodine-125

Iodine-125 emits very low energy gamma radiation. A Geiger-Muller (G-M) detector is not very effective for this type of radiation. Instead, a portable detector with a special low-energy gamma scintillation probe must be used. This probe contains a thin sodium iodide crystal and is particularly efficient for low-energy gamma radiation. Using this probe and depending on the background radiation in the lab, survey Methods 2 or 3 could be used. If it is more convenient, Method 1 may be used instead of or in addition to Methods 2 or 3.

4. Phosphorus-32, Chromium-51, Iron-55, Iron-59, Iodine-131, and Other High-Energy Beta or Gamma Emitters

These radionuclides are readily detected using a hand-held portable G-M detector with a thin window not more than 2 mg/cm^2 in thickness. Depending on the background activity in the lab, the above Methods 2 or 3 would usually be used for surveys. If it is more convenient, Method 1 may be used instead of or in addition to Methods 2 or 3.

5. Combinations of Radionuclides

In situations where laboratories are using various combinations of several different radionuclides, the required surveys will include a combination of techniques. For instance, if a lab uses H-3 and P-32, the after use surveys may be specific for the radionuclide used (Method 1 for H-3 and probably Method 2 is preferred for P-32). However, the monthly survey should employ LSC counted wipes, which are capable of detecting both types of emitters.

E. Where to Survey

1. General Rule

Surveys should be conducted in all areas where radioactive materials is used or stored. Areas where contamination is more likely should be surveyed with greater attention.

2. Particular Areas of Importance

a. Floors and Storage Areas

l) Floors near storage of radioactive materials, including waste.

2) Floors in front of hoods and workbenches.

3) Floors near exit from lab.

4) Interiors of storage areas.

b. Equipment

1) Hood lip and sash.

2) Handles on refrigerators and freezers where radioactive materials are stored.

3) Telephones.

4) Computers/data entry devices.

5) Doorknobs.

6) Instrument dials.

7) Centrifuges.

8) Other miscellaneous items that could be contaminated.

c. Work Surfaces

1) Areas on work bench where work is done.

2) Desks.

F. How to Record Surveys

Monthly surveys must be recorded. If no radioactive material was used in a laboratory during a month, a “No Use” entry as described in Section B.2 above may be recorded in lieu of performing a survey of that laboratory. In labs where the locations surveyed and the instruments used are always the same, this information can be typed onto the standard form and copies used for each survey.

1. Survey Form

The following information must be recorded for any survey form.

a. Identification

1) Room and building surveyed.

2) Name of surveyor.

3) Date of survey.

b. Survey Map

Diagram or map showing facilities surveyed.

c. Instrument

Instrument used to perform survey, including serial number.

d. Results

1) Results of background count.

2) Results of wipe tests and portable instrument surveys.

e. Action Taken

Actions taken for any contaminated areas or items.

2. Mapping Work Space

A sketch of the floor plan of the work area should be used when making surveys, with a number corresponding to each survey location. If wipes are used for taking contamination measurements, the wipes should be numbered with the survey location. This allows easy mapping and evaluation of contaminated areas and aids in locating the source of the contamination.

An alternative to producing a sketch of the floor plan for each survey is to make a detailed drawing with several numbered locations. Then, survey documentation can be attached on subsequent sheets of paper. These subsequent sheets would specify the actual survey locations (by number) and survey results, with inferred reference back to the original drawing.

G. General Laboratory Practices

When performing your required laboratory surveys, it is a good practice to be alert for unsafe laboratory practices or conditions in the lab that could lead to the loss of radioactive materials or to uncontrolled contamination. These are discussed more completely in Section 9 of this manual, Radiation Protection Procedures. Some conditions that should be noted and corrected are:

1. Poor Laboratory Housekeeping

If laboratories are messy and housekeeping is especially poor, these conditions could contribute to the uncontrolled release of radioactive materials.

2. Food and Drink

a. Consumption Not Allowed

1) Food and drink must not be consumed in laboratory space.

2) The presence of food and beverages in radioactive material laboratories at the University of Washington is strictly prohibited, unless in enclosures dedicated only to storage of food and drink.

3) Laboratory glassware/equipment should not be used for food or drink.

4) Food or drink containers should not be used for chemicals or radioactive materials.

5) Avoid creating the misleading appearance that food or beverage was consumed in a laboratory. For example, do not discard drink containers or food in laboratory trash receptacles.

b. Food Storage

1) Refrigerators or enclosures that protect food from radioactive contamination may be used for the storage of food or drink in laboratories. Refrigerators used for this purpose must be clearly marked with an “Only Food and Drink” label.

2) Food or drink must not be stored in enclosures, refrigerators, or cold rooms that contain radioactive materials.

3. Radioactive Waste

a. Proper Disposal

Radioactive waste receptacles should be clearly identified with the proper warning labels, tape, or stickers.

b. Improper Disposal

1) Radioactive waste should not be placed in the hallways.

2) Radioactive waste must not be mixed with normal trash or placed in ordinary wastebaskets.

4. Laboratory Security

Radioactive material laboratories must not be left open and unattended while radioactive materials is accessible.

H. Inspection of Records

Survey records will be inspected periodically by Radiation Safety staff. Laboratories in which records are found to be incomplete or missing will be checked during the next survey. If the records are still missing, further action will be determined at this time.

Table 13-1
Radionuclides Arranged in Hazard Groups
According to Annual Limit on Intake (ALI)

Group I	**Group II**		**Group III**		**Group IV**	**Group V**	**Group VI & Above**
ALI > 10	10 > ALI > 1		1 > ALI > 0.1		0.1 > ALI > 0.01	0.01 > ALI > 0.001	0.001 > ALI
H-3	C-14	Ru-103	Na-22	Ag-110m	Sr-90	I-129	Po-208 * (VI)
Be-7	Na-24	In-111	P-32	Sn-113 *	Ru-106 *	Ra-228	Po-209 * (VI)
C-11	P-33	I-123	Cl-36 *	Ba-133 *	Cd-109 *		Po-210 *(VI)
F-18	S-35	Sm-153	Ca-45 *	Cs-137	In-114m *		Pb-210 (VI)
Cr-51	K-42	Re-186	Sc-46	Ce-139 *	Cd-115m		Ra-226 * (VI)
Cu-64	Fe-55	Hg-193m	Ca-47	Ce-141 *	I-125		Th-228 * (VII)
Ga-68	Co-57	Hg-195m	V-48	Gd-153 *	I-131		Th-229 * (VIII)
Br-77	Co-58	Hg-197	Mn-54 *	Ho-166	Cs-134		Th-230 * (VII)
Rb-81	Ni-63	Tl-204	Fe-59	Yb-169 *	Eu-155 *		U-233 * (VI)
Kr-85	Ga-67		Co-60	Ir-192			U-236 * (VI)
Tc-99m	Ge-68		Zn-65	Hg-203 **			Pu-238 * (VII)
Ag-104	As-73		As-74	Bi-207 *			Pub-239 * (VII)
Ag-106	Br-82		Se-75	Pa-233 *			Am-241 * (VIII)
In-113m	Sr-85		Sr-82				Am-243 * (VIII)
Xe-122	Nb-95		Rb-86				Cm-244 * (VII)
Xe-127	Tc-95m		Y-88				Cf-252 * (VII)
Xe-133	Tc-99		Sr-89				
Tl-201	Mo-99		Y-90				

Groups are based on Annual Limits on Intake (ALI) Values (mCi) from EPA Federal Guidance Report No. 11.

* Group classification based on inhalation ALI - all others based on ingestion ALI
** Organic form - inorganic form in Group II

Section 14

Radioactive Waste

Contents

Tables

A. Proper Collection, Disposal, and Packaging

1. Dry Waste

a. Acceptable

Dry waste consists of paper, gloves, glass, plastics, and other forms of solid waste.

b. Unacceptable

It is forbidden to put the following items in dry waste

1) Uranium and thorium compounds.

2) Liquid in any form.

3) Lead.

4) Animal carcasses.

5) Putrescible waste.

6) Human blood or tissue.

c. Disposal:

1) Dry Waste

Dry waste is collected in the standard Low Specific Activity (LSA) box that has been lined with a plastic bag. See Table 2, at the end of Section 14, for catalog numbers for ordering LSA boxes and plastic bags.

2) Sharps

Sharps include glass pipettes, broken glass, and needles. They should be placed in a strong inner package, which is placed in the LSA box.

2. Liquid Waste

a. Sewer Allowance

The UW is allowed to dispose of material that is soluble or readily dispersible in water into the sanitary sewer, as long as quantities are restricted. A portion of the UW's allowance for sewer disposal is allocated to each lab. Each registered radioactive materials (RAM) laboratory may have a sink or drain designated for liquid radioactive waste disposal.

1) Single Laboratory

The single laboratory allowance for each calendar quarter is as follows:

H-3	1000	μCi
C-14	200	μCi
I-125	100	μCi
All other radionuclides combined	200	μCi

2) Multiple Laboratories

When a group of RAM laboratories are assigned to one Authorized Investigator, the allowance for the group is the sum of the allowance for each lab. For example, if you have six labs assigned to your use, you may dispose of a total of six times the limit given above. **Records of all sink disposals must be maintained by each Authorized Investigator** to show compliance within the limits. Radiation Safety Office (RSO) Form 170, Quarterly Sink Disposal Record for Radioactive Material, is available for this purpose.

3) Release

The soluble or readily dispersible material must be released into a strong flow of water to allow complete purge of traps. Consult the UW Environmental Health and Safety (EH&S) website or call the Radiation Safety Office at 543-6328 for the current list of approved sewer disposable liquid scintillation fluids.

4) Restricted or Not Allowed

a) Restricted Liquid Scintillation Fluids

This restriction includes soluble liquid scintillation fluids that are not approved for sewer disposal.

b) Not Sewer Disposable

Organic solvents or other hazardous materials are not to be disposed of into the sewer.

5) Special Projects

A portion of the University's licensed sewer disposal allowance is held in reserve for special projects, which generate unusual quantities of liquid waste. Permission to make these non-routine disposals should be requested from the RSO.

b. Aqueous Liquid

Aqueous liquids that exceed the sewer allowance are not candidates for sewer disposal and must be absorbed and transferred to Radiation Safety (RS) staff for disposal.

1) Waste Collection Procedures

Only properly packaged aqueous waste will be accepted for disposal by the RS staff.

a) Use plastic pails and lids, which are available from Radiation Safety. Call Radiation Safety for information and for catalog numbers for these supplies.

b) Pails should be labeled with a radiation label and filled only **half-full** with diatomaceous earth, an absorbent. See Table 2 for the catalog number for diatomaceous earth.

c) The lid can be secured and liquid added through the bunghole, or the lid can be left loose.

d) Add liquid waste until it will no longer "soak in."

e) Fill the remaining half volume with diatomaceous earth. **Do not add more liquid.** This will assure the legal disposal of approximately 1.5 gallons of aqueous solution in a 5-gallon pail. Fill the bucket as full as possible with dry absorbent to minimize the void space in the pail.

f) Secure the lid and the bunghole plug.

g) Wipe any spilled waste from the top, sides and bottom of the pail.

h) **No items other than aqueous liquid and diatomaceous earth are allowed in pails.**

2) Maximum Allowed Pail Weight:

a) 5-Gallon Pail - maximum pail weight is 38 lbs.

b) 3.5-Gallon Pail - maximum pail weight is 26 lbs.

c) Pails over the appropriate weight or that contain materials other than absorbed aqueous liquid and diatomaceous earth will be returned to the lab of origin for repackaging.

3) Removing Lid

It is not possible to remove the lid from a plastic pail once it has been secured without breaking the binding ring. If a secured lid is removed, it must be replaced with a new lid.

4) Cautions

a) Inhibit Biological Growth

A pail of absorbed liquid waste can serve as an ideal growth chamber and may generate gas when cell culture media or other nutrients decompose. Waste may need to be treated prior to disposal by adding an appropriate growth inhibitor.

b) Biohazard Control, Decontamination

Consult the UW Biohazard Safety Manual, Chapter IV Procedures for Biohazard Control, Part C Decontamination.

c) Possible Side Reactions

An example of a possible side reaction is chlorine bleach releasing chlorine gas or stimulating the volatilization of radioactive iodine.

5) Liquid Scintillation Fluid

This is not considered aqueous liquid, and must be handled separately. See Item 3 - Liquid Scintillation Counting Waste below.

3. Liquid Scintillation Counting (LSC) Waste

a. Bulk LSC Waste

1) Cost

The most economical method of disposing LSC waste is in bulk form.

2) Bulking

LSC waste can be emptied from vials and consolidated into tight-lidded, labeled containers.

3) LSC Bottles

The original LSC bottles in the original cardboard carton are recommended for packaging waste LSC fluid.

b. Vials and Contents

1) Disposal

Vials containing LSC fluid can be accepted by the RS staff for disposal; however, the cost is greater than for disposal of bulk LSC waste.

2) Packaging

LSC vials and contents should be packaged in the original "egg crate" cartons, because loose vials in boxes are prone to leakage. Also, do not use LSA boxes to package vials. An LSA box full of scintillation vials is too heavy for pickup.

c. Safe Handling of LSC Waste

1) Caution During Handling

   a) LSC waste may contain several solvents, including toluene, dioxane, xylene, and/or trimethylbenzene.

   b) Many LSC fluids contain chemicals that are suspected carcinogens.

   c) Inhalation, skin contamination, and fire hazards must be considered in handling LSC waste.

2) Protection during Handling

   a) Filling and emptying LSC vials may require the use of an operating fume hood.

   b) During work individuals should wear gloves, eye protection, and a lab coat.

3) Handling Empty Vials

   a) Empty vials can be re-used or properly disposed.

   b) If vials are to be disposed, they should either be evaporated to dryness or rinsed in a pail of warm detergent water within a ventilated space to eliminate residual solvent vapors, and checked for contamination.

   c) Empty glass vials should be discarded with lab glassware. Empty plastic vials may be discarded in normal trash.

4) Storing Bulk LSC Waste

   Bottles of LSC waste should be stored until collected in cabinets approved for flammable materials.

5) Exceptions

   a) Some newer types of LSC fluid may be safer to use and, therefore, require fewer precautions.

   b) Be sure to consult manufacturer's recommendations before you deviate from the above procedures.

4. Animal Carcasses and Putrescible Animal Waste

a. Non-Radioactive Animal Waste

1) Below Regulatory Limits

Animals contaminated with H-3 or C-14 at a concentration less than 0.05 μCi/gram, or other radionuclides at a concentration below 0.005 μCi/gram can be disposed as non-radioactive waste.

2) Specific Organs

Organs with concentrated radioactivity may be removed and treated separately as radioactive waste if the remainder of the animal is below regulatory limits. See Item b.1) for handling of those specific organs.

b. Radioactive Animal Waste

1) Organs with Higher Levels

If certain organs with H-3 or C-14 concentrated radioactivity at or above 0.05 μCi/gram or other radionuclides at or above 0.005 μCi/gram, these parts can be removed for radioactive waste disposal.

2) Animal Waste above Limits

Putrescible animal waste containing radionuclides greater than the levels listed in Item a.1) above must also be treated as radioactive waste. This includes blood, excreta, tissue samples, animal bedding, and similar materials.

3) Disposal

Animal carcasses, animal organs, or putrescible animal waste containing long-lived radionuclides above the exempt limits **must be transferred to RS staff** for disposal.

4) Packaging for Disposal

To package radioactive animal carcasses, animal organs, and putrescible animal waste, do the following. Waste presented in an incorrect form or which becomes putrid will jeopardize the authorization to use radioactive materials. Putrid packages will be returned to the originating laboratory for proper packaging**.**

a) Seal into two layers of plastic bags.

b) Take to Comparative Medicine, Health Sciences D607 (freezer section).

c) Label with a RAM tag provided in HSB D607. The tag should be filled out with all information required for disposal.

d) Large Animals

When the disposal of large animals is anticipated, arrange with RS staff to have a 30-gallon drum delivered to your work area. The carcass can then be placed in the drum before it becomes rigid. When notified, the RS staff will pick up the drum and take it directly to the freezer in Health Sciences B122.

c. Animal Carcasses Containing Short Half-Lived Materials

1) Holding for Decay

Animals containing only radionuclides with short half-lives can be held for radioactive decay, provided the average activity concentration will be less than 0.005 μCi/gram within six months, to prevent long term storage.

2) Storage

These animals are stored without charge. Make arrangements with the Radiation Safety Office.

3) Labeling

This waste **must be labeled** by the researcher to indicate the date at which the activity of the waste will be below 0.005 μCi/gram.

5. Possible Infectious Wastes

a. Type of Infectious Wastes

1) Human blood.

2) Human tissues.

3) Human wastes of any kind.

4) Animal carcasses or wastes that contain active pathogens.

b. Processing

1) Sterilization

These materials need to be processed in an appropriate manner to sterilize any biological agent.

2) Autoclaving

Autoclaving biological waste that contains radioactive material requires the pre-authorization and written approval of the Radiation Safety Office. Using an autoclave to sterilize radioactive material has been known to cause extensive contamination of the equipment and laboratory spaces if the material is not properly prepared.

3) Incompatible Processing

Some sterilization procedures, such as treatment with chlorine bleach, may be incompatible with control of radioactive materials. Contact the RSO for special review, if you have questions or are uncertain about the appropriate procedure.

6. Fumes and Vapors

a. Atmospheric Releases

The UW is allowed to emit small quantities of radioactive materials to the atmosphere. An evaluation of the potential release, the exhaust stacks, and the exhaust rates must be made and included with other University releases.

1) The Radiation Safety office will assist with this evaluation.

2) Atmospheric release, as part of ongoing research projects, needs to be evaluated by Radiation Safety staff. You must present a detailed discussion of your plans in the application to use radioactive materials or in an application for amendment to your authorization.

7. Incineration

At present, there is no provision in the University license or local pollution prevention laws to permit incineration of radioactive materials.

8. Storage for Decay

a. Waste That Can Be Stored for Decay

1) Short-Lived Radionuclides

Short-lived radionuclide waste can include almost all radionuclides on campus with a half-life of 100 days or less. Radionuclides, such as tritium and carbon-14, have a half-life greater than 100 days, and, therefore, cannot be held in storage for decay.

2) Acceptable Locations for Storage

Short-lived radioactive materials may be stored for decay in the User's facilities or transferred to RS staff for a storage and handling fee. **Putrescible material** is not allowed and should not be included.

b. Criteria for Determining Material Has Decayed

1) Hold for 10 Half-Lives

Waste must be held for at least 10 half-lives prior to disposal, but in some situations this may still not be enough time to decay some high activity sources to background levels.

2) Determine Materials have Actually Decayed

The ultimate determination of decay to background levels usually comes from using a survey instrument that is appropriate for the type and energy of radiation being measured. Also, a survey will assure that no long-lived contaminants are present.

3) Alternatively – Decay to Activity Limit

Solid or liquid short half-lived wastes that cannot be readily measured with a survey instrument (like low energy beta emitters, e.g. S-35) and of known activity, must be decayed to 0.000001uCi/gram (1pCi/gram) prior to disposal.

c. Prior to Disposal of Decayed Materials into Normal Trash

1) Measurement Method

Check the radiation detection survey meter for proper operation and current calibration status prior to use. Monitor waste with the survey instrument in a low-level radiation area away from all sources of radioactive material. Remove any shielding from around the materials being surveyed. Monitor at contact on all surfaces and discard only those wastes that cannot be distinguished from background radiation.

2) Decay Calculation Method

The activity at time of disposal must be determined using appropriate decay equations or tables. Packages must be weighed to enable calculation of final concentrations of solid or liquid wastes.

3) Labels

All radionuclide labels and radiation symbols must be removed or defaced.

4) Internal Labels

Waste given to the RS staff for decay must be properly labeled on the outside, but internal labels and radiation symbols must have been removed or marked out.

d. Record Keeping

1) Required Data

Careful records must be kept of original activity, time of decay, final concentration of radionuclides, and the radiation survey prior to disposal.

2) Records Retention

You must keep these records for three years.

9. Mixed Waste

The University currently does not have a means of disposal for mixed waste. Review laboratory procedures to eliminate the production of mixed wastes. Processes that use or generate materials that could potentially become mixed wastes will not be authorized.

a. Definition

Mixed waste is radioactive waste that has a hazardous waste component.

b. Characteristics and Examples of Mixed Waste

Table 1 is a list of characteristics and examples to help you avoid generating mixed waste. Contact the RSO, 206-543-6328, to assist in researching questions concerning this issue.

Hazardous waste disposal must be consistent with the University's Hazardous Waste Program. Call 206-685-2848 for questions concerning disposal of hazardous waste.

c. Neutralization and Deactivation

In some cases, the hazardous aspect can be neutralized and/or deactivated. The generating laboratory, if appropriate, must do this process.

d. Lead

Lead in any form is not permitted in radioactive waste, since its inclusion with radioactive materials constitutes mixed waste. This includes lead shielding.

10. Lead

Disposal - A laboratory wishing to dispose of lead must segregate it from their radioactive waste, and the RS staff will collect it at no charge.

Table 14-1
Characteristics of Hazardous Waste

Characteristic	Description	Examples
Flammable	Liquids with a flash point less than 140°	Methanol, xylene, other solvents
	Solids which spontaneously ignite in air or can ignite through friction or absorption of moisture	Zinc dust, pyrophoric organometallic compounds
Oxidizer	Compounds which promote combustion	Potassium, permanganates, chromic acid
Corrosive	Liquid with a pH less than 2 or greater than 12.5	Sulfuric acid, ammonium hydroxide
	Solids which, when mixed with an equal part water, will form solutions with a pH less than 2 or greater than 12.5	Ferric Chloride
Reactive	Unstable compounds which may explode	Picric acid, perchloric acid, lead azide
	Compounds which react violently with water	Metallic sodium and potassium
	Compounds which may produce toxic gases when in contact with water or acids	Acetyl chloride, sodium cyanide
Toxic	High acute toxicity to mammals by ingestion, inhalation, or skin absorption (measured by median lethal doses in laboratory animals)	Phenol, mercury salts, lead, organophosphates
	High toxicity to fish (measured by laboratory aquatic toxicity tests)	Chromic acid, silver salts
	Compounds possessing high organ-specific toxicity	Carbon tetrachloride
Environmentally Persistent	Halogenated hydrocarbons 4-, 5-, and 6-ring polycyclic aromatic hydrocarbons	Trichlorethylene Benzo (a) pyrene, 3-methylcholanthrene

11. Uranium and Thorium Compounds

a. Separation

Uranium and thorium compounds may **not** be mixed with other radioactive waste forms.

b. Disposal

Uranium and thorium waste must be collected separately by the RS staff.

B. Records and Labeling

The University's license requires that we maintain records of inventory and control on all aspects of work with radioactive materials.

1. Waste Disposal Records

a. Radioactive Material Delivery and Usage Record (Form 160)

A Form 160 is provided with each shipment of radioactive material. Indicating the disposal methods of the radionuclide on the Form 160 and returning it to the RSO reduces your inventory. The Authorized Investigator should retain copies of these records, for at least three years, to be available for inspection and to verify disposal of inventory.

b. Disposal Log

To establish how much radioactive waste is involved in the following processes, the Authorized Investigator should maintain a log for each mode of disposal.

1) You may use RSO Form 150 to record how much activity is in each container. This form is optional and available from the Radiation Safety Office. Form 150-type records should be totaled to determine the approximate values for labeling the contents of each filled waste container. This information should be consistent with that on Form 160, but scrupulous correlation is not necessary.

2) Use RSO Form 170 to record the amount of radioactive waste released to the sewer.

3) You must also keep track of the amount of radioactive materials released to the atmosphere. This may be recorded on RSO Form 160.

2. Marking Packages for Collection

Packages that are full and ready for collection must be securely closed and marked or labeled to show the following information:

- Authorized Investigator's name
- Phone #
- Budget #
- Mail Box #
- Radionuclide(s)
- Total activity of each radionuclide
- Laboratory of origin

- RAM tape or label (see C.2.b. - Marking Waste Containers)

C. Other Items of Importance

1. Designation of Radioactive Waste Containers

Clearly label each waste container with a sign to indicate radioactive waste. Use the standard radiation sign or a strip of radioactive tape.

Since custodians occasionally collect radioactive waste by mistake, handmade hazard signs and handwritten messages are not adequate. Some custodians may not be able to read or interpret them correctly. Also, do not use “Laboratory Glassware” tape to secure radioactive waste boxes closed.

2. Radioactive Material Labels

a. Purpose of Labels

Do not misuse RAM labels. RAM labels are intended as a warning. Improper use of labels causes unnecessary alarm and leads to disregard for the proper warning.

b. Removal of Labels

A container that once contained radioactive material should have labels or signs removed or marked out before the container is discarded or placed in storage.

3. Security

Radioactive waste containers **should not** be placed in hallways or unsecured areas.

4. High Exposure Level Waste

a. “Hot Project” Waste

Waste from a special project that involves high radiation activity (hot project) should be sealed up immediately for early removal from the work area. Smaller packages can be used if normal packages are too large.

b. Disposition

Prior arrangements may be made to schedule the early collection of "hot" packages. However, researchers must be prepared to store it in their laboratory until collection is possible.

5. Waste Containers

Standard radioactive waste containers should be used **only** for radioactive materials.

6. Ventilation of Containers

a. Proper Ventilation

Vapor and fumes may accumulate above waste containers. Therefore, waste receptacles should be in or near a fume hood or other ventilated space.

b. Adding Waste

Partially full containers should be allowed to ventilate "down wind" when opened to add more waste.

7. Radioactive Material Waste Fees

a. Determination of Waste Fees

The Washington Utilities and Transportation Commission determines the fees for radioactive waste disposal in our state.

b. Changing Rates

In general, disposal rates can be expected to rise. Waste disposal costs fluctuate depending on market factors such as:

1) Broker costs.

2) Total disposal volumes from the entire northwest region.

3) Taxes.

4) State and waste-site license fees.

c. University Costs

The disposal prices charged to individual researchers are equal to University of Washington costs. Call the RSO for specific price information (206-543-0463).

Table 14-2
Catalog Numbers for Ordering Waste Supplies

Contact Radiation Safety For Information

#	Item	Catalog #
	Section – Food Services & Janitorial Supplies	
1	LSA Box	0737042
2	Plastic Liner	0060132
3	5-Gallon Plastic Pail	0737237
4	3.5-Gallon Plastic Pail	0737240
5	Diatomaceous Earth	0737236
	Section – Hardware, Electrical, Plumbing	
	Lead	6451030

Section 15

Sealed Sources

Contents

This section covers sealed radioactive sources. Sealed sources are used for special applications where encapsulated radioactive material is quantified and protected from disbursal. Only radiation capable of penetrating the capsule is of interest, and the emitted radiation has a calibrated intensity. Sealed sources are commonly used to provide precise dose rates for medical treatment, biological experiments, or materials testing. Sometimes, sealed radioactive sources are contained within analytical equipment, like gas chromatographs, and the user must be attentive to the presence of these sources.

A. Security

Sealed sources are typically small in size and can be quite portable. Because of this, extra attention must be given to security. Sealed sources and the instruments or devices that contain them must be secured whenever left unattended.

B. Authorization Requirements

All individuals possessing non-exempt sealed sources must apply for an Authorization for Sealed Source Use from the UW Radiation Safety Office. Non-exempt quantities are activities greater than 10 μCi for sources designed to emit alpha particles and greater than 100 μCi for beta/gamma emitters.

1. Newly Acquired Sealed Sources

The purchase of sealed sources is controlled as described previously in Section 4 – Authorization Process. Newly acquired sealed sources usually have recent leak test certification records included with source calibration and documentation. Copies of these leak test certifications must be forwarded to the Radiation Safety Office, Box 354400, for inclusion in UW records.

2. Portable Gauges

Portable gauges containing sealed sources are authorized for use in specific locations. If the portable gauge is intended for use in multiple locations, the user must comply with transport requirements in Section 12 - Shipment of Radioactive Materials.

3. Relocation of Sealed Sources or Devices Containing Sealed Sources

The location of sealed sources is carefully monitored and recorded by the Radiation Safety staff to facilitate leak testing and inventorying requirements described above. If it becomes necessary to move a source to a new location, either permanently or for an extended period, you must notify the Radiation Safety Office (543-0463) prior to the move.

If the move will result in the source becoming inaccessible for leak testing by the Radiation Safety staff, special arrangements must be made. Special arrangements could include: performing leak tests immediately preceding the move, as in the case of a temporary relocation of the source; performing tests by laboratory personnel *in absentia*; or the transfer of the source from the UW to a new owner, who will then take responsibility for the tests.

4. Transfer of Sealed Sources

Equipment or analytical devices containing sealed sources of radioactive materials are inventoried. If you intend to transfer the equipment to another user or send it to UW Surplus Property, you must notify the Radiation Safety Office (543-0463) prior to that transfer.

a. Another UW Owner

Transfer to another user within the University cannot be done unless the recipient has a UW Sealed Source Authorization.

b. Non-UW User

Transfer to a non-UW user requires verification that the recipient has a valid Radioactive Materials license.

c. UW Surplus Property

Sealed sources are normally removed from equipment being sent to UW Surplus Property, unless it can be verified that the recipient has a valid Radioactive Materials license for the acquisition of the source.

5. Training

Training requirements and Authorization application procedures are described in Section 4 - Authorization Process.

C. Sealed Source Leak Tests

Some sealed sources are of such low activity that they do not require leak testing. However, most sealed sources require semi-annual or quarterly tests to assure integrity of the encapsulation. In addition to these tests, sealed sources must also be inventoried, typically every quarter. Sealed source leak tests and inventories are conducted by the Radiation Safety staff.

1. Sealed Beta/Gamma Emitters

Leak tests of sealed beta/gamma emitters generally consist of wiping the exterior of the source and counting the wipes with appropriate instrumentation. Leak test results are recorded on RSO Form 188 and are kept in the Radiation Safety Office for review by DOH inspectors.

2. Sealed Alpha Sources

Radioactive materials emitting non-penetrating radiation, such as alpha particles, are sometimes plated on the surface of a metal backing and minimally coated with a protective film. These sources are called sealed sources for regulatory purposes, but are not strictly sealed sources since the coating and underlying plating can be easily damaged. Radiation Safety staff takes wipe tests only on adjacent surfaces and does not touch the surface of calibrated alpha particle sources.

3. Suspected Damage of Sealed Sources

If at any time there is reason to suspect that a sealed source might have been damaged, it must be leak tested and not used until the leak test results are quantified and source integrity has been verified.

D. Control of work with high activity sealed sources

Work with sealed sources containing high activities of radioactive material requires extra precautions and planning. The Radiation Safety Officer (RSO) must approve any installation, relocation, resourcing, removal, or other non-routine service of the gamma knife, any irradiator, any industrial radiography source, or any other sealed source as deemed necessary by the RSO. Prior to commencing any work with these sources, the contractor performing the work must obtain a temporary Authorization for Sealed Source Use from Radiation Safety.

1. Work Planning

The contractor conducting the work must submit the following to Radiation Safety at least 90 days prior to the beginning of any work.

- A detailed schedule of the work being performed
- Information on the instrumentation that will be used during performance of the work
- Training and experience of the individuals performing the work
- Up-to-date procedures for the work being performed, including emergency procedures with job-specific contact information and work stop information identified.
- A work plan that specifies
  - Hold points
  - Surveys necessary to monitor radiological condition during the proposed activities
  - Potentially limiting conditions related to the work being performed
  - How the work plan will be modified under unexpected or abnormal circumstances
  - Roles and responsibilities for
    - safety oversight
    - control of security zones (if applicable) and radiation areas
    - safety and job task briefings
    - conducting surveys
- A determination of whether or not there is a potential to emit as defined in WAC 246-247-030 (21). This determination shall account for all processes involved in the proposed activities.

2. Work Approval

Radiation Safety will review the information provided by the contractor, and determine if additional hazards require review by other sections of EH&S. If needed, EH&S will designate a project team that includes multiple EH&S and University subject matter expertise such as occupational safety and health, emergency management and preparedness, UW Facilities, and Building management. This team will conduct a thorough review of procedures to identify potential hazards (including potential radiation exposures), conduct a risk analysis of those hazards, identify risk mitigation techniques, and provide feedback to contractors on work plans and procedures regarding necessary safety requirements. Once satisfied with the work plan and procedures, Radiation Safety will issue an Authorization for Sealed Source Use signed by the Radiation Safety Officer.

3. Approval by Department of Health

Work on sealed source(s) containing a quantity equal to or greater than Category 1 or Category 2 levels of any radioactive material listed in the table in WAC 246-237-900 Appendix A must be approved by DOH. The Authorization for Sealed Source Use, and all documentation submitted by the contractor, will be submitted to DOH for review and approval. DOH requires a minimum of 30 days for review, and work may not commence until written approval from DOH is obtained.

Glossary

accelerator (*particle accelerator)* - A machine that accelerates charged sub-atomic particles (electrons, protons, deuterons, etc.) to high speed and energy. These high-speed particles are often bombarded upon a suitable target and uncharged high-energy radiation is subsequently produced (neutrons or x-rays).

ALARA - An acronym formed from the phrase "As Low as Reasonably Achievable." The phrase refers to a radiation safety principle of keeping radiation doses and releases of radioactive material to the environment as low as can be achieved, based on technologic and economic considerations.

alpha decay - Alpha decay is a type of radioactive decay giving rise to the emission of alpha particles, and resulting from instabilities within the nucleus of atoms with high atomic number.

alpha particle *(alpha ray)* - A type of radiation emission given off during the decay of some high atomic number radionuclides. The alpha particle is a very densely ionizing radiation composed of a packet of two neutrons and two protons (exactly like the helium nucleus). This type of radiation readily interacts with matter, looses its energy very quickly while traveling through matter, and therefore is not very penetrating. Most alpha particles can be stopped with a thin sheet of paper.

annual limit on intake (ALI) - A mathematically derived intake limit for a single radionuclide taken into the body of an adult worker by inhalation or ingestion in a year. This derived limit is based on radionuclide emission characteristics, half life, and assumptions about typical human biology. The 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 0.05 Sv (5 rem) or a committed dose equivalent of 0.5 Sv (50 rem) to any individual organ or tissue. ALI values determined for intake by ingestion or inhalation of selected radionuclides are given in WAC 246-221-290.

authorized investigator (AUI) - A principle investigator authorized by the Radiation Safety Office who becomes legally responsible for the handling of radioactive material under their jurisdiction. The Authorized Investigator (AUI) is usually a faculty member or a medical doctor.

beta decay - Beta decay is a type of radioactive decay giving rise to the emission of beta particles, and resulting from an unstable proton to neutron ratio within the nucleus of an atom.

beta particle *(beta ray)* - A type of radiation emission given off by radionuclides having an unstable neutron to proton ratio. The beta particle is identical to an electron, except it is created within the nucleus of the atom during radioactive decay. A negatively charged beta particle (negatron) is given off when beta decay results from too many neutrons within the unstable nucleus of an atom. A positively charged beta particle (positron) is given off when beta decay results from too many protons within the unstable nucleus of an atom.

calibrate - To check, adjust, or systematically standardize the graduations of a quantitative measuring instrument.

contamination (*radioactive*) - Deposition of radioactive material in any place where it is not desired.

decay (*radioactive*) - A spontaneous re-arrangement within the nucleons of an atom, converting it into another type of atom and resulting in the emission of radiation.

dose (*absorbed dose*) - Radiation dose refers to the concept of absorbed dose, or the amount of ionizing radiation energy absorbed per unit mass of material of interest. The historical unit of absorbed dose is the rad (100 erg/gram), but the SI unit of absorbed dose is the Gray (1 Gy = 1 Joule/Kg). Conversion between SI and traditional units yields 1 Gy = 100 rad.

dose equivalent - A concept which attempts to account for the different biological consequences resulting from different types and energies of radiation at the same absorbed dose. To apply this concept, the absorbed dose in gray or rad is multiplied by a quality factor (Q) related to the biological damaging ability of the radiation. A quality factor of 1 is given to x-rays, gamma rays, and beta particles. Alpha particles are given a quality factor of 20, and neutrons of unknown energy are given a quality factor of 10. The resulting units of dose equivalent are the sievert (Sv) in SI units or the rem in historical units.

dosimeter - A device that measures and indicates the amount of x-rays or other radiation absorbed.

dosimetry - The act of quantifying ionizing radiation under specified conditions.

exposure - Often used as a verb indicating being subjected to ionizing radiation or radioactive material. When used as a noun, exposure is the quotient of the absolute value of the total charge of ions of one sign produced in air when all the electrons liberated by photons in a given volume element of air are completely stopped in air. The special unit of exposure is the Roentgen (R). One Roentgen is equal to 2.58×10^{-4} Coulomb per kilogram of air. The SI unit of exposure is the Coulomb per kilogram.

fluoroscopy - A diagnostic x-ray procedure, which produces a “real-time” image. To produce this image, the x-ray equipment is energized continuously or in regularly timed pulses and the image is projected onto a fluorescent screen or the image is electronically manipulated for viewing on a television monitor.

gamma ***(gamma ray)*** **-** A high energy electromagnetic radiation emitted from the nucleus of an atom, resulting from release of residual energy after an atom undergoes a primary mode of radioactive decay (beta decay, alpha decay, or fission).

gamma counter - A radiation detection device that counts flashes of luminescence resulting from interactions of ionizing radiation with solid detection medium. This detection medium (scintillant) is often a specially grown transparent crystal. In addition to the detection medium, the gamma scintillation counter contains a light amplification device and electronics to convert light signals to electronic pulses. The pulses are registered on a counter or averaged over time on a ratemeter

Geiger-Mueller counter ***(Geiger Counter, G-M Counter)*** **-** A Geiger-Mueller counter is a radiation detection device useful for several types of radiations. The device contains a G-M tube, which produces a voltage pulse whenever an ionizing radiation event interacts with gasses in the sensitive volume of the tube. The total number of pulses are registered on a counter or averaged over time on a ratemeter.

liquid scintillation counting ***(LSC)*** **-** A radiation detection device that counts flashes of luminescence resulting from interactions of ionizing radiation with a liquid scintillation fluid medium ("liquid scintillation cocktail"). The radionuclides being measured are immersed in an intimate mixture with the LSC fluid. In addition to the detection medium, the liquid scintillation counter contains a light amplification device and electronics to convert light signals to electronic pulses. Liquid scintillation counters are particularly suitable for detecting low energy beta emitters that have very short range in matter.

radiation - Generic term meaning matter (particulate radiation) or energy (electromagnetic radiation) moving outward from a source of origin. Often used to mean ionizing radiation, or high-energy radiation capable of removing electrons from atoms.

radioactive material - A substance that contains one or more radionuclides, and which emits one or more types of radiation (alpha, beta, gamma, etc.).

radionuclide - An atom having a combination of neutrons and protons which cause the nucleus to be unstable.

Roentgen - A unit of exposure or ionization produced in a given volume of air by photons. One Roentgen is equal to 2.58 x 10^{-4} Coulomb per kilogram of air.

scintillation counter - A radiation detection device that counts flashes of luminescence resulting from interactions of ionizing radiation with various media. In addition to the detection medium, the scintillation counter contains a light amplification device and electronics to convert light signals to electronic pulses. The pulses are registered on a counter or averaged over time on a ratemeter. Also, see "gamma scintillation counters" and "liquid scintillation counters."

SI units - The International System of Units (Le Systeme Internaltional d'Unites), which is an international unification of rules for units of measurement in the metric system.

x-rays - Ionizing electromagnetic radiation produced by: 1) the movement of electrons from higher to lower energy levels within the electron shells of an atom, or 2) from the loss of energy when high speed electrons are deflected by interactions with the atomic nucleus.