ENVIRONMENTAL HEALTH & SAFETY

UNIVERSITY of WASHINGTON

RADIATION SAFETY MANUAL

MAY 2023

Environmental Health and Safety Department

University of Washington

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SECTION 1 – EMERGENCY PROCEDURES

Contents

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

A. EMERGENCY PHONE NUMBERS

1. Campus

a. **Radiation Safety Office**.....**206-543-0463**

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 EH&S Duty Officer.

2) Give them your name and number.

3) Someone will call you back.

B. RADIATION EXPOSURE RESPONSE

If an individual is exposed to radiation from a radioactive source, x-ray machine, or other source of radiation, the EH&S Exposure Response poster (Figure 1) provides guidance for actions to take. This poster must be posted in each space where exposure to radiation is possible from radioactive materials or radiation producing machines – except for clinical spaces within UW Medicine facilities, which maintain their own emergency response posters.

Additional considerations in response to a radiation exposure include:

- Call Radiation Safety at 206-543-0463 immediately in any of the following situations (when in doubt, call Radiation Safety at 206-543-0463):
    - Skin contamination
    - Ingestion of radioactive material
    - Unexpected personnel exposure
    - Severe contamination of equipment or areas
    - Spread of contamination, or difficulty cleaning up a contaminated area
    - Loss, theft or damage of radioactive materials or radiation producing machines
- For radiation producing machines, de-energize the machine by turning off the power supply. Report all pertinent information about the incident, including operating voltage and current, exposure time, and distance from the radiation source.
- Notify all personnel in the room and secure the area to prevent access to the area, source, and/or machine.

C. SPILL RESPONSE

If radioactive material is spilled or if radioactive material contamination is found during a survey, the EH&S Spill Response poster (Figure 2) provides general guidance for actions to take. This poster must be posted in each space where unsealed radioactive material is used – except for clinical spaces within UW Medicine facilities, which maintain their own emergency response posters.

A major spill is one which occurs in a public space or other uncontrolled area (e.g., hallways, break rooms, etc.), requires securing access to an area to prevent the spread of contamination, and/or requires major resources to contain or clean up. Major spills must be reported to Radiation Safety, and Radiation Safety staff are available to assist or advise personnel in case of minor spills or contamination in lab spaces, which may (or may not) be an emergency.

Keep in mind these key actions (S.W.I.M.) to take in response to any spill or discovery of contamination.

Key actions in response to a spill.

S: **Stop** the spill. Cover with absorbent material.

W: **Warn** others. Alert people in the immediate area of the spill.

I: **Isolate** the spill and secure the area. Close doors if possible.

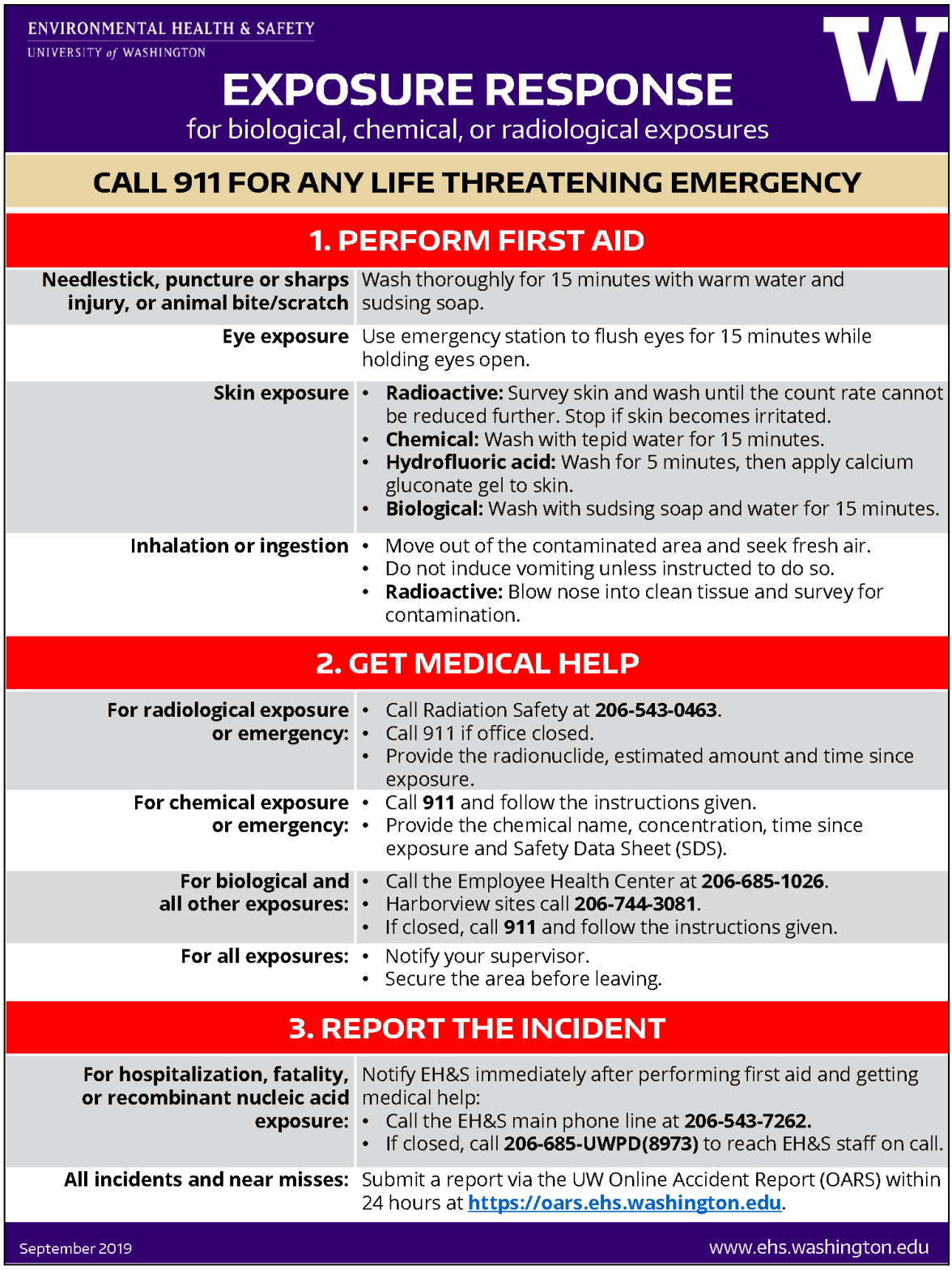
M: **Minimize** your exposure by wearing PPE and avoiding contact, inhalation, or ingestion. Vacate the area if necessary. Wash hands after handling spill materials.

Additional considerations in response to a radioactive material spill or contamination include:

- Isolating the spill may include securing ventilation (e.g., building supply and exhaust, Biological Safety Cabinets, fume hoods, etc.) in the space and/or building. This will help minimize the spread of contamination, especially if it has the potential to go airborne.
- Contact Radiation Safety for assistance in evaluating and cleaning the spill or contamination. Radiation Safety must be informed of a major spill (refer to definition above).
- After the emergency has passed, perform appropriate surveys and decontamination procedures detailed in SECTION 9 – RADIATION PROTECTION PROCEDURES and SECTION 13 – LABORATORY SURVEY PROCEDURES.

Figure 1 EH&S Exposure Response Poster

Click on the image for the most recent version available on the EH&S website.



ENVIRONMENTAL HEALTH & SAFETY
UNIVERSITY of WASHINGTON

EXPOSURE RESPONSE

for biological, chemical, or radiological exposures

CALL 911 FOR ANY LIFE THREATENING EMERGENCY

1. PERFORM FIRST AID

Needlestick, puncture or sharps injury, or animal bite/scratch	Wash thoroughly for 15 minutes with warm water and sudsing soap.
Eye exposure	Use emergency station to flush eyes for 15 minutes while holding eyes open.
Skin exposure	• **Radioactive:** Survey skin and wash until the count rate cannot be reduced further. Stop if skin becomes irritated. • **Chemical:** Wash with tepid water for 15 minutes. • **Hydrofluoric acid:** Wash for 5 minutes, then apply calcium gluconate gel to skin. • **Biological:** Wash with sudsing soap and water for 15 minutes.
Inhalation or ingestion	• Move out of the contaminated area and seek fresh air. • Do not induce vomiting unless instructed to do so. • **Radioactive:** Blow nose into clean tissue and survey for contamination.

2. GET MEDICAL HELP

For radiological exposure or emergency:	• Call Radiation Safety at **206-543-0463**. • Call 911 if office closed. • Provide the radionuclide, estimated amount and time since exposure.
For chemical exposure or emergency:	• Call **911** and follow the instructions given. • Provide the chemical name, concentration, time since exposure and Safety Data Sheet (SDS).
For biological and all other exposures:	• Call the Employee Health Center at **206-685-1026**. • Harborview sites call **206-744-3081**. • If closed, call **911** and follow the instructions given.
For all exposures:	• Notify your supervisor. • Secure the area before leaving.

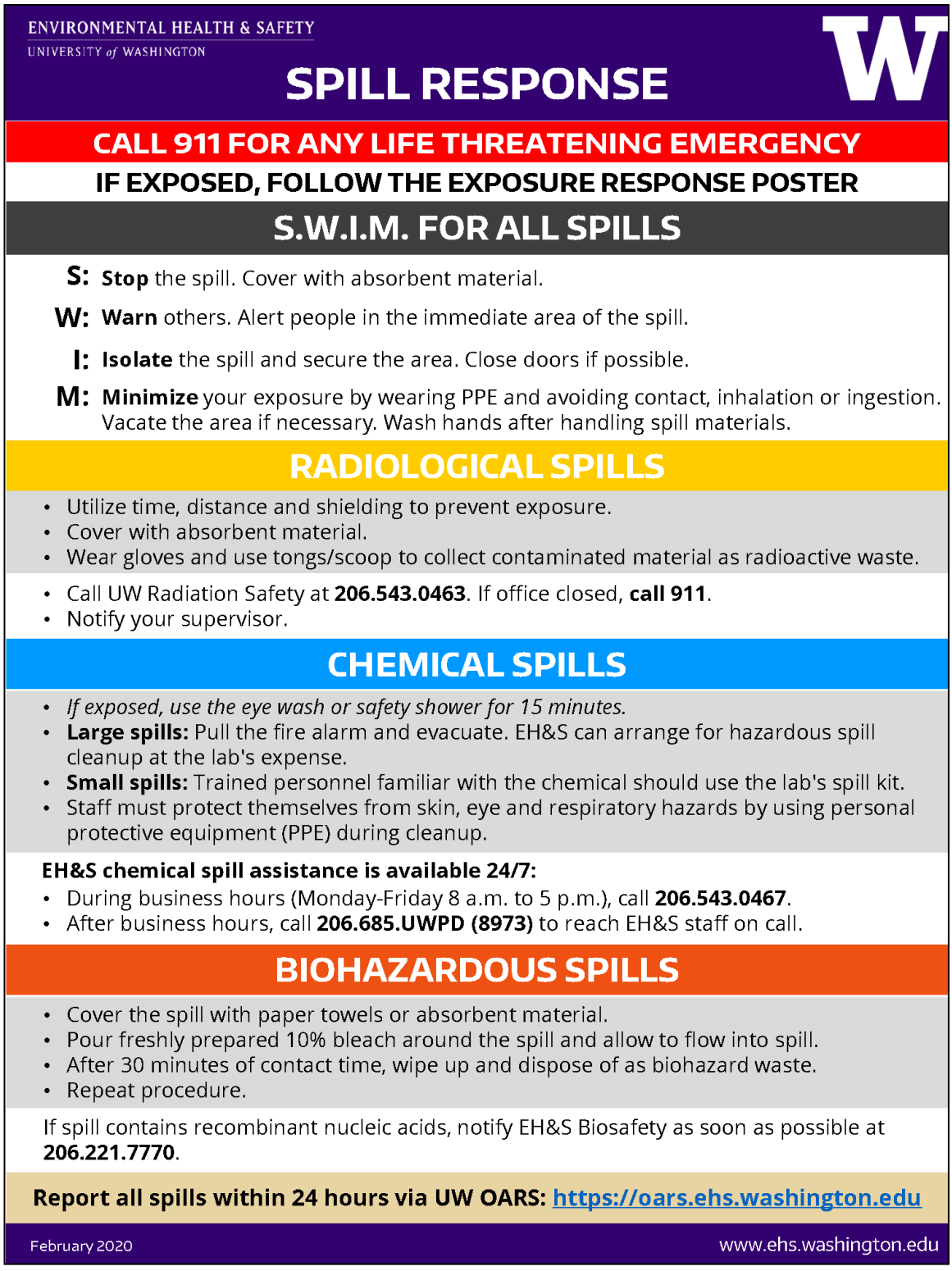
3. REPORT THE INCIDENT

For hospitalization, fatality, or recombinant nucleic acid exposure:	Notify EH&S immediately after performing first aid and getting medical help: • Call the EH&S main phone line at **206-543-7262.** • If closed, call **206-685-UWPD(8973)** to reach EH&S staff on call.
All incidents and near misses:	Submit a report via the UW Online Accident Report (OARS) within 24 hours at **https://oars.ehs.washington.edu**.

September 2019 www.ehs.washington.edu

Figure 2 EH&S Spill Response Poster

Click on the image for the most recent version available on the EH&S website.



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SECTION 2 - LICENSING AND REGULATORY CONTROLS

Contents

Radioactive materials and radiation producing machines in the State of Washington are licensed or registered through the Washington State Department of Health, Office of Radiation Protection (DOH). 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 Washington State Department of Health (DOH). This "Agreement State" status allows the state to exercise local control over the use of certain radioactive materials. 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 every 18 to 24 months and take 3 or more days to complete. 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 – SEALED SOURCES.

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:

- East Seattle Campus
  - Sports Medicine Clinic
- West Seattle Campus
  - Applied Physics Laboratory
- North Seattle Campus
  - Hall Health Clinic
  - Center for Experimental Nuclear Physics and Astrophysics (CENPA)
- South Seattle Campus
  - University of Washington Medical Center – Montlake
  - Health Sciences Building
  - School of Dentistry
- UW Medicine Eastside Specialty Clinic
- UW Medicine Roosevelt Clinic
- Harborview Medical Center
- University of Washington Medical Center – Northwest
- School of Medicine South Lake Union
- Washington Clean Energy Testbeds
- Friday Harbor Laboratory
- The Center for Pediatric Dentistry (Sandpoint)

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.

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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 Washington State 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 protection 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. INSTITUTIONAL AUTHORITY

Authority for the radiation protection program at the UW 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 has appointed the Senior Director of Environmental Health and

Safety (EH&S) to provide supervision and administrative support for the radiation safety program. Also, the President's Chief of Staff appoints the members of the University of Washington Radiation Safety Committee to 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 UW Radiation Safety Committee (RSC) is charged with formulating and 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 RSC:

a. Responsibilities

1) Review and Approve Applications

a) Ionizing Radiation

All uses of ionizing radiation on or within property that is owned by or leased to the UW and operated by UW personnel.

b) Human Subjects

All research or experimental programs supported by or through the UW, which require approval by the UW Human Subjects Radiation Approval Committee (HSRAC) 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 Policies

Establish policies 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 EH&S.

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 protection program.

6) Advising Senior Director

Advise the Senior Director of EH&S 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 (RSO).

b) Specify possession limits and general restrictions to define those uses of ionizing radiation that can be authorized directly by the RSC Chair and the RSO, acting together.

3) Restriction

Direct the RSO and appropriate UW 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 RSO 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) Procedure/Policy Development

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

7) Radiation Safety Manual

Review and endorse the Radiation Safety Manual.

8) Radiation Safety Officer (RSO)

Participate in the selection of the RSO.

9) Annual Audit

a) Conduct an annual audit of the radiation protection program which will include reviewing a report of RS operations, examining required records and written procedures, reviewing results of the State Department of Health (DOH) inspections, and resulting UW 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 UW President's Chief of Staff.

10) Delegate Authority

Delegate authority to the RSO, or to the RSO and the RSC Chair 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 RSC typically meets once each quarter, but additional meetings may be called by the RSC Chair. A meeting quorum is at least one half of the current membership, with at least one of the members being either the RSO or the RSC Chair.

D. RADIATION SAFETY OFFICER (RSO)

The RSO is responsible for the day-to-day coordination and management of the radiation protection program.

1. Management Reporting Structure

The RSO is appointed by the UW President's Chief of Staff and reports to the Senior Director of Environmental Health and Safety (EH&S). The Senior Director of EH&S reports to the UW President.

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 Senior Director of 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 RSO has the authority to prevent the use of any radiation source or radioactive material that either the RSO or RSC has not properly authorized.

4. Authority to Impound

a. Non-Compliance

The RSO 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 RSO has the authority to impound any radiation source or radioactive material that is not properly authorized by the RSC or the RSO.

5. Radiation Safety Staff

The RSO position is a full-time assignment and is supported by adequate staffing to implement the radiation protection program.

6. Responsibilities

a. Administration

1) Manage the administrative aspects of the Radiation Safety section (RS) of EH&S, under general direction of the Senior Director of EH&S.
2) Supervise the RS staff, including offering recommendations to the Senior Director of EH&S on hiring, promotion and disciplinary action, and conducting performance evaluations.

b. Resources and Facilities

1) Manage RS resources and facilities .
2) Recommend budget or other resource needs to the Senior Director of EH&S.

c. Advising EH&S Director

1) Advise the Senior Director of EH&S on the status of the radiation protection 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 Senior Director of EH&S to allow performance of management obligations.

e. Quarterly Report for Radiation Safety Committee

Provide a quarterly report to the RSC regarding the radiation protection program activities.

f. Approving Radiation Use

Approve the use of radiation within limits of authority delegated to the RSO by the RSC.

g. Radiation Safety Manual

Revise the UW Radiation Safety Manual and administrative procedures for the radiation protection 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 UW.
2) Package and ship or assist with the proper packaging and shipping of radioactive material leaving the UW.

m. Radionuclide Inventory

1) Maintain an inventory of all radionuclides at the UW. The inventory shall include the name of the Radiation Use Authorization (RUA) holder responsible for each quantity of a radionuclide, where it will be used or stored, and the date the quantity was received and disposed of by the RUA holder.
2) Limit the quantity of radionuclides at the UW to the amounts authorized by the license and by RUAs.

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 a RUA holder, 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 UW.

2) Notify instrument owners when calibration is needed.

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.

5. Radiation Safety section, EH&S

The Radiation Safety (RS) section of EH&S provides oversight to UW 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 interpret regulations and establish programs to assure their compliance.

However, a more fundamental purpose of the radiation protection 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 RUA holders. Information on campus resources or commercial systems that are unfamiliar to RUA holders 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. A RUA holder may request these services, but the RSO 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 RS. The stringent requirements of the Department of Transportation must be met in shipping radioactive material, as well as any hazardous material.

e. Radioactive Waste

Policies on radioactive waste disposal methods are established by RS and must be followed. RS staff will work with RUA holders 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 a need develops.

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. Radiation Use Authorization Assistance

Assistance is available to ensure that RUA 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.

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SECTION 4 – RADIATION USE AUTHORIZATION PROCESS

Contents

A. AUTHORIZATION TO USE RADIOACTIVE MATERIALS

Individuals are authorized to use radioactive materials via a Radiation Use Authorization (RUA) issued by the Radiation Safety Committee (RSC). The RUA defines specific conditions of radioactive material use and is an extension of the University's radioactive materials license.

B. RUA HOLDER

RUAs are issued to individuals who are affiliated with the UW to operate under the UW Radioactive Materials License of Broad Scope; these individuals are called RUA holders.

1. Criteria

The authorized individuals (RUA holders) are usually a Principal Investigator in a research lab, a clinical director or department chair for the medical use of RAM, or other individuals as approved by the RSC.

The Principal Investigator (PI) is an individual who is designated and given the authority by a University academic or clinical department, school, or administrative unit using radiation or radioactive materials to direct the program, project, or clinic. The PI has appropriate training and experience to direct the scientific and technical aspects of the work being done and has been granted the authority to direct funding and to enforce regulations and policies related to working with radiation or radioactive materials, including worker safety. This includes ensuring that the facilities are appropriate for the work being done, and for ensuring that personnel who will be involved with the work are trained. Any application with an assigned PI who does not fall within this definition will be considered on a case-by-case basis.

2. RUA Holder versus Radiation Worker

An individual that desires to use radioactive material must either hold an active RUA or be listed as a Radiation Worker on an active RUA.

a. RUA Holder

An RUA Holder directs and supervises a project and is responsible for the coordination and management of the radiation protection program requirements for work performed under the RUA.

b. Radiation Worker

A Radiation Worker is listed on an RUA and is authorized to work independently with radioactive materials.

3. RUA Holder 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 RUA holder or their 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 RS of acquisitions of new instruments.

d. Posting

1) Work with RS to post all areas under RUA holder 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 RS whenever changes in operational procedures, facilities, personnel, or equipment occur that may lead to changes in personnel exposure.

C. APPLICATIONS TO USE RADIOACTIVE MATERIALS

1. General Laboratory Use of Radioactive Materials

An investigator seeking to become a RUA holder for non-human use of radioactive material should contact RS or go to the EH&S website for Radioactive Use Authorization forms.

a. Application Forms

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) RS Safe Operating Procedure

SOP Template for radioactive material study procedures to be evaluated by RS.

b. Short-Term RUA

A Short-Term RUA may be issued to the UW or visiting scientists, or contractors planning to use radioactive materials for a limited period at UW facilities at the discretion of the RSO or RSC. If a visiting scientist is planning multiple visits, they must inform Radiation Safety of the start date and duration of the intended work before each visit. A Short-Term RUA will be issued for a fixed duration.

c. Sea Vessel RUA

A Sea Vessel RUA is issued for work with radioactive materials onboard research sea vessels that are owned, leased, and/or operated by the UW. Application for a Sea Vessel RUA must be made six months prior to the start of the cruise. Sea Vessel RUAs are valid for the length of the cruise.

2. Clinical Use

RUAs are issued for radioactive materials used in Nuclear Medicine and Radiation Oncology Departments at UWMC–Montlake, UWMC–Northwest and Harborview Medical Center.

a. Nuclear Medicine

The medical use of radioactive materials as diagnostic tracers or therapy is covered under an authorization for Clinical Use in Nuclear Medicine. The Director of that program shall be appointed as the RUA holder.

A Nuclear Medicine radioactive material use authorization requires a completed application as well as other requirements specified by Radiation Safety at the time of the application.

b. Radiation Oncology

The medical use of radioactive sources for brachytherapy to treat cancer is covered under an authorization for Clinical Use in Radiation Oncology. The Director of that program shall be appointed as the RUA holder.

A Radiation Oncology radioactive material use authorization requires a completed application as well as other requirements specified by Radiation Safety at the time of the

application.

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 will complete the online Sealed Source Training and will need to have initial RUA-specific training commensurate with the risks of the materials they will be using or to which they may be exposed.

c. Application Forms

An investigator seeking to become a RUA holder for non-human use of radioactive sealed sources should contact RS or go to the EHS website for RUA forms.

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

D. HUMAN SUBJECTS APPLICATIONS

All research involving human subject volunteers must be reviewed and approved by an Institutional Review Board (IRB). If research involves human subject exposure to radiation, the Human Subjects Radiation Approval Committee (HSRAC), a joint sub-committee of the UW and Fred Hutch Cancer Center (FHCC) Radiation Safety Committees, must also review each protocol. The HSRAC review focuses on informing the enrolled subjects of their radiation risk. The HSRAC verifies 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

All research involving the use of radioactive materials, medical or dental diagnostic x-rays, or therapeutic radiation in human subjects must first meet certain criterion.

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

Human Subjects Radiation Approval Committee (HSRAC) Application Form. This is the general form that can be used for any protocol, and covers the use of radioactive materials, x-rays, and fluoroscopy. This form covers new applications, renewals, and amendments to existing authorizations.

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.

E. REVIEW OF INITIAL APPLICATION

The completed application must be submitted to RS. 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.

F. 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 Washington State 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 RUA holder.

G. RENEWAL

1. General Laboratory or Sealed Source Use

Authorizations are renewed by RS every five years. 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.

H. 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 RSC or a decision of the Radiation Safety Officer and/or the Scientific Executor, can be made to the RSC.

a. Basis

An appeal of an RSC 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 people who have a qualified interest in the decision considered the decision improper.

b. Submittal

An individual effected by a RSC decision, a RSC member, or a person who has a qualified interest in the decision, should present an appeal to the Chair 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 RSC Chair, with the advice of the Scientific Executor, the RSC Chair must either return the matter to the RSC to be reheard or present the appeal to Executive Office of the President and Provost .

d. Second Hearing

If a second hearing by the RSC results in a continuing basis for appeal, the appellant should request that the RSC Chair present the issue to the Executive Office of the President and Provost.

2. Limitation of Appeal

RSC action to deny use of radiation is normally final. However, the Executive Office of the President and Provost may refer the action back to the committee if proper procedures were not followed.

I. AMENDMENTS

Requested changes will be subject to the same review and approval process as was the original application. The RUA holder is notified of the approval of a change through an amendment to their authorization.

1. Major Changes

If a RUA holder wishes to make several major changes to their authorization, it may be necessary to conduct a review of the entire program. The decision as to whether a complete review is necessary will be made by the Radiation Safety Officer.

2. Forms

A RUA holder may request changes to their authorization by submitting the requested change 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 email.

b. Personnel

Form 20 – Used to add a participant to the authorization. The RUA holder may inform RS of personnel terminations by email.

c. Laboratory Registration

1) New Lab

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

2) Termination

Requests to terminate laboratories may be accomplished by 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.

J. TERMINATION OF RUA

Prior to closing a laboratory or other area where radionuclides have been used or stored, the RUA holder must develop a plan for terminating these areas.

1. Notification

Prior to termination, advance notification must be given to RS. 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. Other offices within UW Environmental Health and Safety Department also need advance notification for decommissioning activities, such as chemical disposal.

2. Radioactive Materials/Radioactive Waste

The RUA holder must arrange for the transfer of any remaining radioactive materials to another RUA holder, or submit a radioactive waste collection request for any radioactive materials or radioactive waste left in their possession.

3. Decontamination

Decontaminate all laboratory surfaces. Contact RS if surfaces cannot be decontaminated to background radiation levels as measured with an appropriate detector.

4. Termination Survey

RS will perform a termination survey after all radiation use has ceased and decontamination has been completed.

5. Financial Responsibility

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

K. RADIATION WORKER

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

1. Application

Any person who wishes to be approved as a radiation worker must submit a completed Form 20 to RS. Note that this application must be submitted only with the knowledge of an RUA holder.

Form 20 may be submitted for an individual at the time of the RUA holder's initial application for project approval or at any time thereafter. The RUA holder will be notified of the approval of personnel additions to their project through an amended authorization.

2. Training

Online radiation safety training courses are available on the EHS website. Radiation workers using unsealed radioactive material will complete the online Radiation Safety Training. Radiation workers handling sealed sources will complete the online Sealed Source Training. Radiation workers using uranyl compounds will complete the online Uranium Use Radiation Safety Training. Training must be completed before the worker is added to the authorization and before the worker handles radioactive materials. This training is in addition to job specific training is required to be given by the RUA holder or their designee (refer to SECTION 5 – RADIATION SAFETY TRAINING).

a. New Authorization

A new RUA holder and the staff that will be put on the authorization must take the appropriate online 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 appropriate online Radiation Safety Training Course.

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SECTION 5 – RADIATION SAFETY TRAINING

Contents

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 (UW) 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 by Radiation Safety (RS).

b. Training for Specific Laboratories

It is also recommended that each RUA holder provide instructions to all personnel on specific radiation safety concerns for the 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 RUA holder.

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 UW. 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 RUA holder is responsible to ensure all individuals listed on the authorization, including the RUA holder, complete the refresher training within the time-period specified by RS. 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 RS to bypass some of the online modules at Radiation Safety Officer'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 UW, 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 RS.

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

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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 and WAC-246-221.

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. Eye Dose Equivalent

The eye 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 eye 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 or 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 1 square centimeter. 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 246-221). 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 the 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, and to the extremities are:

An eye dose equivalent of 0.15 Sv (15 rem); and
A shallow dose equivalent of 0.5 Sv (50 rem) to the skin or 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 specified above for adults.

3. Occupational Dose to an Embryo or Fetus

The dose 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 Radiation Safety (RS) 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 who 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 RS. 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 contact RS at radsaf@uw.edu or 206-543-0463.

b. Formal Declaration of Pregnancy

Given this is a formal request to change your occupational dose limits, you must submit the proper information to RS.

1) To declare a pregnancy, request the application form(s) from RS. 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 by contacting RS at radsaf@uw.edu or 206-543-0463.

3) If you are a radiation worker who does not have a dosimeter, but still wish to declare pregnancy contact RS at radsaf@uw.edu or 206-543-0463.

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 Doses

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. RS 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 contact RS at radsaf@uw.edu or 206-543-0463 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 Radiation Safety

It is a declared pregnant worker's responsibility to contact RS 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 RS 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, RS will work with you and the Disability Services Office to facilitate 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 by 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 RS at radsaf@uw.edu or 206-543-0463.

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 ADC for each area.

c. Privacy

If privacy is desired, check the box marked "yes" under the question "Is this report to be kept confidential?" on RSO Form 9. We will mail the fetal dosimetry results directly to you instead of to the ADC.

You are not required to disclose the declaration of pregnancy to anyone outside of RS. However, if your job duties or schedule must be modified 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, your doctor should consult with the radiologist who read the diagnostic x-ray or nuclear medicine physician who read the nuclear medicine exam.

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, 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 RS 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, and 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, and 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, and 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.

3. Application for Dosimetry Service

Personnel dosimeters are provided to the UW community by RS. To facilitate the distribution of dosimeters, each group using dosimeters is assigned a Series Code and has an appointed Area Dosimetry Coordinator (ADC).

a. Area Dosimetry Coordinator (ADC) Responsibilities

1) Submits dosimeter applications to RS.
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, contact RS at radsaf@uw.edu or 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) Radiation Worker and Dosimetry Application – RSO Form 20
2) Request for Fetal Monitoring – RSO Form 9.

If confidentiality is preferred, call the RSO for a Form 9 instead of contacting the ADC. Mark the request "confidential" in the box provided on Form 9. Refer to SECTION 6 – PERSONNEL EXPOSURE AND MONITORING, C. Declared Pregnant Worker for more information.

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. Contact RS at radsaf@uw.edu or 206-543-0463 for individual badges.

5. Over Exposure Notifications

In addition to notifications to individual workers, RS is required to report doses exceeding the maximum permissible dose limits (listed under SECTION 6 – PERSONNEL EXPOSURE AND MONITORING, B. Dose Limits) to the State of Washington Department of Health, Division of Radiation Protection.

E. BIOASSAY AND INTERNAL DOSIMETRY

The UW 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 principal 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. Requirements

Each person who directly works with 1 millicurie (mCi) or more, over a three-month period, of volatile or dispersible radioiodine is enrolled in the thyroid bioassay program. Thyroid bioassays are taken in the following circumstances:

1) Baseline

A baseline measurement is taken before beginning work with quantities of radioiodine that require enrollment in the bioassay program.

2) Routine

Measurements of I-123 shall be taken less than 24 hours after the beginning of the operation.

Measurements of I-124, I-125 or I-131 should be taken between 8 and 72 hours after the beginning of the operation.

Bioassay frequency can be additionally specified in the RUA conditions at the discretion of Radiation Safety. For example, if personnel are consistently using radioiodine, then a regular bioassay frequency (e.g., monthly, or quarterly) can be required.

3) Emergency

As soon as possible after any incident that might cause thyroid uptakes to exceed the predetermined action levels below. Additional follow-up bioassays may also be required.

b. Predetermined Action Levels (PALs)

Thyroid bioassays are made with an instrument that is calibrated for measuring various forms of radioiodine in the thyroid. A mathematical model is used to equate the measurement of radioiodine in the thyroid to the rest of the body. Depending on the amount measured, the following actions (based on Regulatory Guide 8.20) will be taken:

1) No dose recorded – Less than the LLD or less than 1 mrem

Thyroid bioassay instruments have a lower limit of detection (LLD) that is calculated at calibration time. If a bioassay measurement falls below the LLD for the instrument, then the measurement is indistinguishable from background, and therefore no dose is recorded.

The dosimetry vendor, Landauer, has a one mrem dose recording threshold. Only doses of one mrem or greater, and are above the LLD for the instrument, are recorded with Landauer.

2) Dose recorded – Between 1 mrem and 2% of the ALI

If a calculated dose from a bioassay is greater than 1 mrem, but less than 2% of the non-stochastic Annual Limit of Intake (ALI) no further action is necessary, but the dose will be reported to Landauer, and will be available on the annual NRC Form 5 occupational exposure history report.

3) Evaluation level – Between 2% and 10% of the ALI

If the measured dose is between 2% and 10% of the non-stochastic ALI, an evaluation is performed to determine if the dose is from radioiodine intake. If so, then the dose is recorded for the individual. This involves:

- A repeat bioassay performed within 24 hours of the last measurement to confirm the presence of intake
- Calculating and recording the internal dose from radioiodine
- Radiation Safety will provide an annual report of internal dose records to every individual who received a verified dose above the evaluation level

4) Investigation level – 10% or greater of the ALI.

If the measured dose is 10% or greater than the non-stochastic ALI, an investigation of the operations involved will be performed, including air and other surveys, to determine the causes of exposure and to evaluate the potential for further exposures. This involves:

- A repeat bioassay performed within 24 hours of the last measurement to confirm the presence of intake
- Calculating and recording the internal dose from radioiodine
- Corrective actions that will eliminate or lower the potential for further

exposures should be implemented

2. Tritium (H-3)

a. Requirements

Each person who works in a laboratory where one of the conditions below is met is required to enroll in the tritium bioassay program:

- Anyone working with more than 100 mCi of H-3 in a single use must have a bioassay within one week of each use.
- Anyone working with a throughput of more than 100 mCi in a month must have a bioassay once per month.
- When H-3 is in gaseous form, leaks are detected into the laboratory/workspace.

Exceptions to these requirements are:

- When H-3 is contained in any sealed source
- When it is absorbed on metal foils
- When the H-3 is in gaseous form, a small portion of the overall activity (less than 100 mCi per month) is used in the experiment.

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.

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. The internal dose can be calculated if the concentration in urine is determined. A mathematical model is used to equate the measurement of H-3 in the urine to the rest of the body. These procedures will either be performed by RS, or by an external CLIA (Clinical Laboratory Improvement Amendments) accredited lab.

F. PERSONNEL EXPOSURE RECORDS

1. Monthly Reports

a. Processing

Dosimeters are returned to the dosimetry company for processing on the last workday of each month. The dosimeter results are then usually received by RS no later than the 20th of the next month.

b. Dose Reports

Dose reports are sent to ADC from Environmental Health and Safety Assistant (EHSA)

c. No Exposure Reading

A blank in a location where a radiation dose reading should be indicates that the dosimeter was missing or returned as unused for that wear period. If the dosimeter is

lost, report it to RS.

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 RS.

An individual may request information about their exposure history at any time by contacting RS at radsaf@uw.edu or 206-543-0463.

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 UW, or at some combination of UW along with other facilities. If an individual goes to work at another facility while still employed by the UW, 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 UW must inform RS if another employer (concurrently) monitors their radiation exposure. This information must be provided in writing to RS 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 UW before working for the other facility or if the individual works at a job that does not require dosimeters or bioassays.

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SECTION 7 – ALARA PROGRAM

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 protection 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 (UW) 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 UW's radiation protection 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 (RS) 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 consider 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 to ALARA.

2. Designated Authority

The RSC designates authority to the Radiation Safety Officer (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 RSC.

3. Annual Review

A formal review of the radiation protection program is performed annually by the RS staff. This includes reviews of operating procedures, past dose records, inspections, etc. This review is reported to the UW management through the UW President's Chief of Staff.

C. RADIATION SAFETY COMMITMENT TO ALARA

1. Radiation Safety Officer

The RSO enforces the ALARA program through management and technical supervision of RS 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 RUA holders 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 RSO reports these instances to the RSC.

f. Training/Consultation

Provide worker training or consultation.

D. MANAGEMENT COMMITMENT TO ALARA

Deans, department heads, division chiefs, principal investigators, unit leaders, and other responsible individuals, in consultation with RS, 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 exposure unless the cost is considered to be unjustified (refer to SECTION 7 – ALARA PROGRAM, I. Cost-Benefit Analysis in ALARA).

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 RS.

b. Dosimeters

Wear a personal radiation dosimeter if one is assigned and exchange it promptly as directed by RS.

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 RSC. A notification and work-assessment survey 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 facilities or experiments under consideration.

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SECTION 8 – WORKERS RIGHTS AND RESPONSIBILITIES

Contents

Washington Administrative Code (WAC) 246-222 establishes requirements for notices, instruction, and reports by the University of Washington (UW) to individuals engaged in work with radiation. The Code further provides options available to such individuals in connection with Washington State 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 UW with the DOH.

A. POSTING OF NOTICES TO WORKERS

1. Radiation Safety

The 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 office spaces for UW Environmental Health and Safety (EH&S), Radiation Safety (RS), in room T245of the Health Sciences Building.

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 University of Washington Medical Center Montlake and Northwest, Harborview Medical Center, University of Washington Seattle Non-Human Use, Nuclear Physics Laboratory, UW Medicine Roosevelt Clinics, School of Dentistry, Sports Medicine Clinic, Friday Harbor Labs, Washington Clean Energy Testbed, and UW Medicine at South Lake Union.

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 UW.

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 DOH 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 DOH 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 UW 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 RUA holder or their designee.

1. Storage, Transfer, Use

All radiation workers shall be kept informed of the storage, transfer, or use of sources of radiation authorized by the RUA. This is the responsibility of the RUA holder or their 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 DOH by oral or written notification. The notification shall set forth specific grounds for the complaint. Any such notification to the DOH is confidential.

b. Improper Actions

A radiation worker has the right to notify the DOH 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 a satisfactory response is not received from their supervisor, they may then contact the UW RSO.

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 – PERSONNEL EXPOSURE AND MONITORING.

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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. Lead of 1/16 inch thickness will shield the weak gamma photons from I-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 or 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 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." Refer to 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 are available to provide assistance in decontamination, if necessary. Refer to SECTION 1 - EMERGENCY PROCEDURES, C. Spill Response 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 commonly used in research laboratories at the University of Washington (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, their 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 in eating areas, such as cafeterias.

c. Respirators

The use of respirators for protection from airborne radionuclide hazards is not a preferred option at the UW. 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 UW in particularly dusty operations involving radioactive materials, such as removing air filters from particle accelerator exhaust ducts.

The Environmental Health and Safety Department (EH&S) has specific requirements for individuals using respirators. For further information, please refer to the Respiratory Protection webpage on the EH&S website.

Contact RS (206-543-0463 or radsaf@uw.edu) 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 RS. Refer to SECTION 5 – RADIATION SAFETY TRAINING.

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 the appropriate Radiation Use Authorization (RUA). Refer to Chapter 4 – Radiation Use 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 RUA holder 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 RS (206-543-0463 or radsaf@uw.edu) 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 RS (206-543-0463 or radsaf@uw.edu). An investigation may include a follow-up inspection by the Washington State Department of Health (DOH).

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 RUA holder 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. The specific retention requirements for radiation protection records which must be maintained by RUA holders is provided on the General Records Retention Schedule for Environmental Health and Safety and Facilities available on the UW Records Management Services website at https://finance.uw.edu/recmgt/gs/ehs?combine=Radiation&title=.

a. Radioactive Material Delivery and Usage Record (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 RS for database entry. The RUA holder or RUA contact may also log on to EHSA and click Inventory to submit a Form 160 in lieu of returning the Form 160 to RS.

The RUA holder must keep a copy of Form 160 for five years after the material is completely disposed. See Refer to SECTION 11 – PROCUREMENT OF RADIOACTIVE MATERIALS for a further description of the use of RSO Form 160.

b. Radioactive Waste Disposal Records (RSO Forms 160 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 160 or on the Environmental Health and Safety Assistant (EHSA) page at on the EH&S website. When the package of waste is ready for transfer to RS, totals from the Form 160 must be included with the package. Form 160 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. Refer to SECTION 14 – RADIOACTIVE WASTE for more information on waste collection, packaging, and recording.

3) Atmospheric Release

The release of radioactive material to the atmosphere must be recorded on the RSO Form 160 or on the Environmental Health and Safety Assistant (EHSA) page on the EH&S website.

c. Survey Records

Records of radiation surveys must be kept in the laboratory for examination by RS staff and DOH inspectors. Refer to 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 RS staff also attaches a calibration record 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 RS 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 later.

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 RUA holder.

5. Reportable Incidents

To protect radiation workers and the public, certain situations must be reported to RS, and may need to be further reported to the DOH on an immediate basis. Contact RS (206-543-0463 or radsaf@uw.edu) 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 RS 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 RUA.

b. Standard Operating Procedure (SOP) for working with radioactive materials

A Standard Operating Procedure (SOP) for working with radioactive materials will be in writing and readily available to all laboratory personnel. Personnel working with radioactive materials must be trained on the SOP at least annually. The SOP must include information on:

- Personal protective equipment (PPE) and personnel monitoring
- Hazard controls
- Waste management
- Emergencies
- Notifications
- Experimental description and processes
- Other hazardous materials

A SOP Template is available on the EH&S website which contains all of the required information.

c. Emergency Procedures

Emergency procedures must be posted in all areas where radioactive materials are used. Refer to SECTION 1 - EMERGENCY PROCEDURES and SECTION 10 – AREA CLASSIFICATION AND POSTING.

7. Radionuclide Use in Animals

The Institutional Animal Care and Use Committee (IACUC) 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 take a longer period of time, animals must be held in facilities approved by the IACUC.

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 RS. A RSO Form 50 must be filled out for the space and submitted to RS. Space may be assigned either for a short period of time, "short-term use", or for a longer period of time. Please indicate on 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. RS staff will advise the RUA holder 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 for 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 of Radionuclide Use

a. Termination of RUA

The process for terminating an RUA is provided in SECTION 4 – RADIATION USE AUTHORIZATION PROCESS, J. Termination of RUA.

b. Termination of a radioactive material use areas and equipment

When work with radioactive materials will no longer be conducted in an area authorized on a RUA or with equipment designated for work with radioactive material, the RUA holder must verify that all areas and equipment are free from contamination. The RUA holder must then inform RS that the area or equipment is ready for a termination survey. RS will then perform a termination survey to confirm that contamination levels meet regulatory requirements for unrestricted use.

9. Hospital Use of Radiation

The use of radionuclides at the University of Washington Medical Center (Montlake and Northwest campuses) 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

The 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 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 EH&S personnel. 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 radiation 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. The 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. UW RS 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. Refer to 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. Refer to SECTION 14 – 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.

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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. Form RH-3 can be viewed on the DOH website.

Washington State Department of Health

Radiation Protection

NOTICE TO EMPLOYEES

Employer University of Washington

Radioactive Materials License # WN-C001-1

X-Ray Registration # 178019988001-0013, 0024, 0033, 0062, 0065, 0079, 0080, 0081, 0083

State standards are designed to protect you against radiation hazards

Washington Administrative Code Title 246, chapters 220 through 254

This RHF-3 notice must be conspicuously posted so that employees working in or entering any portion of a radiation "restricted area" will see it.

Your employer is required to:

- Comply with regulations pertaining to sources of radiation.
- Post or otherwise make available to you a copy of Department of Health regulations, licenses and operating procedures that apply to your work, and explain them to you.
- Post each Notice of Noncompliance involving radiological working conditions, and other orders by Department of Health.
- These documents are available at:

  1705 NE Pacific Ave, Rm. T245, Seattle WA 98195
- Provide adequate radiation safety training to you, including the use of radiation-producing devices or radioactive materials you may be expected to use.
- Keep your radiation exposure as far below the maximum allowable limits as is "reasonably achievable."

As an employee, you must:

- Familiarize yourself with those provisions of the state regulations, and the operating procedures, which apply to your work.
- Follow their provisions for your own protection, the protection of your co-workers, patients, clients, and the public.
- Immediately report any violations of the requirements that you observe, or safety concerns you may have to your supervisor. You may also report directly to Department of Health.

Your radiation exposure history:

- Your employer must inform you annually, in writing, of your exposure to radiation if monitoring is required by Department of Health.
- 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. Exposure limits for employees are defined in WAC 246-221-010, 246-221-050, and 246-221-055 of the regulations.
- If you quit your employment, you may ask for a written report of your exposure during the current year up to the date you quit. This may be an estimate as long as it is identified as such.

Inspections:

- Department of Health may inspect any licensed or registered activity. During inspections, you may tell the inspectors about past or present conditions you believe contribute to or caused problems with work involving radiation.
- Department of Health inspectors want to talk to you if you are worried about radiation safety or have related concerns. Your employer must not prevent you from talking with an inspector. We will make all reasonable efforts to protect your identity.
- Any worker or worker representative who believes there is noncompliance with Chapter 70.98 of the Revised Code of Washington, the radiation regulations, or the terms of your employer's license or registration involving the worker's radiation working conditions, may request an inspection by the Department of Health. The request must specify exactly what is wrong, and must be signed by the worker or worker representative.

Deliberate misconduct: You must not do anything to deliberately cause a violation of state requirements. You must not deliberately provide inaccurate or incomplete information to either Department of Health or your employer. If you do, you may be subject to enforcement action. This does not apply to "mistakes" or actions that weren't planned.

Reporting safety concerns and violations

Radioactive materials: 360-236-3220
Radiation-producing machines and facilities –X-ray: 1-800-299-XRAY (9729)
By mail: Office of Radiation Protection, Washington State Department of Health, P.O. Box 47827, Olympia, WA 98504-7827.
Website: www.doh.wa.gov/ehp/rp

For people with disabilities, this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TDD/TTY call 711). DOH 320-098 August 2013

B. "CERTIFICATE OF AUTHORIZATION"

A sign bearing the words "Radioactive Materials Certificate of Authorization" must be posted in any room authorized on a RUA for the storage or use of radioactive materials. The information on this Certificate is typically filled in by RS staff.

C. "EMERGENCY PROCEDURES"

Pertinent emergency procedures must be posted in areas where radiation may be encountered, and as required by Washington State Department of Health. Laboratories at the UW where radioactive materials are used have a standard posting. The Environmental Health and Safety (EH&S) Exposure Response Poster and Spill Response Poster are posted in laboratories at UW locations. Both posters are available for download from the EH&S website.

If an individual is exposed to radiation from a radioactive source, x-ray machine, or other source of radiation, the Exposure Response Poster provides guidance for actions to take.

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.

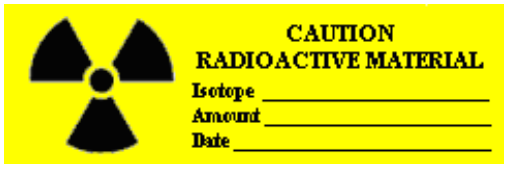
2. When Used

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

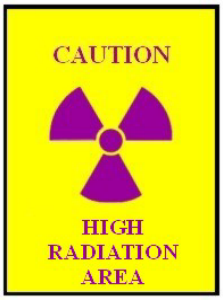
Food and beverage intended for human consumption must not be stored in refrigerators or freezers used for the storage of radioactive materials. Laboratory refrigerators, ice chests, and cold rooms are not allowed for food or beverage storage.

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***.

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.

References:

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

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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 Radioactive Use Authorization (RUA)to possess such material in the type and quantity requested. The authorization for possession and use of radioactive materials is issued through Radiation Safety (refer to SECTION 4 – RADIATION USE AUTHORIZATION PROCESS). Specific radionuclides and activity limits are indicated in the authorization.

B. ORDERS

Orders for radioactive materials are made through Workday. Radioactive materials are listed as an *exception item* and must be purchased using the spend category "Radioactive Materials" SC2070. A guide for Radioactive Material requisition is available on the UW website.

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 (RS). For more information on ordering radioactive materials refer to the Radiation Safety - Control of Radioactive Materials webpage on the EH&S website.

C. APPROVAL OF RADIONUCLIDE ORDER

All radioactive material orders entered in the Ariba Spend Management System are sent to RS for review and approval before being sent to the vendor. RS grants approval primarily based on a comparison of the RUA's current inventory to the allowed limits of the RUA.

D. RADIOACTIVE MATERIALS INVENTORY

The University of Washington (UW) maintains an inventory of all radioactive material on campus. The running inventory is updated when researchers either order new material, submit a Radioactive Material Delivery and Usage Record (Form 160), or enter disposal information directly into EHSA.

1. Possession Limits

The RUA holder's possession limit of radioactive material is the amount a RUA holder is allowed to have in their possession at any one time. Possession limits are listed on the RUA.

2. Amount On-Hand

The amount on-hand is specific to each nuclide and indicates the activity the RUA holder has in their 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 UW yet. Approved orders are added to the amount on-hand on the authorization and reduce the activity that a RUA holder 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 RS staff deliver material to the appropriate laboratory, the packages are checked for damage, contamination, and exposure rates.

5. Delivered Orders

A Radioactive Material Delivery and Usage 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. Notify RS if the information on Form 160 is incorrect or if the wrong package was delivered.

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

The Radioactive Material Delivery and Usage Record (Form 160) is used to remove items from the RUA holder's inventory by recording the disposal pathway. The RUA holder or RUA contact must fill out this form and return it to RS. 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 Form 160. Partial disposals are only used in special circumstances and require prior approval by RS.

c. Transfer

It is possible to transfer radioactive material to another RUA holder or institution. However, RS 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 RS has documentation of this authorization.

d. Entering disposals into EHSA through PI Portal

The RUA holder or RUA contact may also log on to EHSA and click Inventory to submit a Form 160 in lieu of returning the Form 160 to RS.

E. INVENTORY REPORTS

The UW radioactive materials license requires that the radioactive material inventory be updated continuously. Therefore, RUA holders are responsible for tracking and accounting for radioactive material used under their authorization. RS will assist the RUA holder in maintaining their inventory by distributing inventory verification reports (IVRs) at regular intervals and issuing a Radioactive Material Delivery and Usage Record (Form 160) for all new radioactive material purchased under the RUA. It is essential that the IVRs and Forms 160 are submitted 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, RS will email each RUA holder a report of their current radionuclide inventory to complete in the EHSA PI Portal. The RUA holder or RUA contact is required to verify that the information provided on the report is accurate and then submit the verification to RS. Verifications and disposals can be performed through the EHSA PI Portal.

Submittal of the Inventory Verification Report (IVR) is necessary to meet the conditions of the UW radioactive materials license, and therefore the submission of the IVR will be strictly enforced. A RUA holder will be allowed 30 days to submit 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 RS until the IVR is submitted.
- The RUA holder 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 RUA holder's department head and/or dean as necessary. The RSC may also decide to place a restriction on the RUA to use radioactive material as deemed necessary to ensure compliance.

2. Other Inventory Reports

At any time, labs can review their current inventory through EHSA PI Portal.

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SECTION 12 – SHIPMENT OF RADIOACTIVE MATERIALS

Contents

A. SHIPPING REGULATIONS

The Nuclear Regulatory Commission (NRC), the Department of Transportation (DOT), and the Washington State 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). RS 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 (UW) 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 (RUA).

C. PORTABLE DEVICES CONTAINING SEALED SOURCES

RS 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 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 secure locations and are subject to periodic testing and inventory (refer to SECTION 15 – SEALED SOURCES).

D. TRANSPORT WITHIN THE UNIVERSITY SYSTEM

To protect the university community, RS 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 UW 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 webform 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 on the EH&S website.

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 **six months** prior to the date of shipment.

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SECTION 13 – LABORATORY SURVEY PROCEDURES

Contents

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 Radiation Use Authorization (RUA) holder and the radiation workers listed on their RUA 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 on the RUA.

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 (RS). 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 with everyone involved when contamination is found.

6. Radiation Safety Surveys

RS staff perform contamination surveys to satisfy Washington State Department of Health (DOH) requirements for administrative oversight. These surveys are conducted on a monthly, quarterly, semiannually, 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 that exceed the action level (200 cpm for beta/gamma and no detectable alpha) on a wipe must be reported on the survey form and action taken to clean the area(s), dispose in appropriate waste container, or

clearly label with a "**Caution, Radioactive Materials**" label.

e. Resurvey after Cleanup

To ensure that the cleanup was successful, the area surveyed, 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 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. Refer to 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. RS operates an instrument calibration facility. The cost of meter calibration by RS are comparable to other calibration facilities. Advantages of using RS for instrument calibration 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 the 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 two times 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 two times 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 is also 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/cm2 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 can detect 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. 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 13 – LABORATORY SURVEY PROCEDURES, B. Survey Frequency, 3. Monthly Surveys – Entire Laboratory may be recorded in lieu of performing a survey of that laboratory.

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 Workspace

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.

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 – 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 UW 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 are accessible.

H. INSPECTION OF RECORDS

Survey records will be inspected periodically by RS 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

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SECTION 14 – RADIOACTIVE WASTE

Contents

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.

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 University of Washington (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 laboratory authorized for radioactive material (RAM) work may have a sink or drain designated for liquid radioactive waste disposal.

1) Single RUA Holder

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 RUA Holders

When a workspace is authorized for RAM work by multiple RUA holders, the sewer allowance for that space is the sum of the allowance for each RUA holder. For

example, if there are six RUA holders authorized to use RAM in the same space, the total activity that may be disposed into the sanitary sewer in that space is six times the limit given above. **Records of all sink disposals must be maintained by each RUA holder** 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 a complete purge of traps. Consult the UW Environmental Health and Safety (EH&S) website or contact EH&S Radiation Safety (RS) at radsaf@uw.edu or 206-543-0463 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 UW'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 RS.

b. Aqueous Liquid

Aqueous liquids that exceed the sewer allowance are not candidates for sewer disposal and must be absorbed and transferred to RS staff for disposal. Aqueous waste must be packaged in a sturdy plastic carboy or equivalent container.

3. Liquid Scintillation Counting (LSC) Waste

It is most economical to collect LSC waste in the vials used to analyze the samples. LSC waste that has a concentration of H-3 or C-14 greater than 0.05 μCi/gram or that contains any other isotope may be considered mixed waste. Refer to SECTION 14 – RADIOACTIVE WASTE, A. Proper Collection, Disposal, and Packaging, 9. Mixed Waste for information on disposing of mixed waste.

a. Vials and Contents

1) Disposal

Vials containing LSC fluid can be accepted by the RS staff for disposal.

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.

b. 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 to be 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.

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 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. Refer to 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, 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** 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) Packaging

Seal the waste in two layers of plastic bags and submit an online Radioactive Waste Collection Request on the EH&S website.

b) Large Animals

When the disposal of large animals is anticipated, arrange with RS 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 the RS waste facility.

c. Animal Carcasses Containing Short Half-Lived Materials

Animals containing only radionuclides with short half-lives can be held for radioactive decay in a freezer authorized for storage of radioactive materials.

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 Officer (RSO). 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. Prior to any sterilization procedure, contact RS for a review of the procedure.

6. Atmospheric Releases of Fumes and Vapors

The UW is allowed to emit small quantities of radioactive materials to the atmosphere. However, an evaluation of the potential release, the exhaust stacks, and the exhaust rates must first be conducted and included with other UW releases. The RS staff will assist with this evaluation.

Atmospheric release, as part of ongoing research projects, needs to be evaluated by RS staff. Detailed procedures must be included in the application to use radioactive materials or in an

application for amendment to an existing RUA.

7. Incineration

At present, there is no provision in the UW radioactive materials license or local pollution prevention laws to permit on campus 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 120 days or less. Radionuclides, such as tritium and carbon-14, have a half-life greater than 120 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 RUA holder's facilities or transferred to RS for a storage and handling fee. Putrescible material is not allowed and should not be included.

b. Length of Storage

Short-lived radioactive waste must be held for decay until the longest condition below is met.

1) Time Held

Waste must be held for at least 10 half-lives.

2) Decay Limit

Waste must be decayed such that it is indistinguishable form background radiation levels.

c. Prior to Disposal of Decayed Materials into Normal Trash

1) Package Survey

Packages must be surveyed to assure no long-lived contaminants are present.

2) Decay Calculations

The current activity must be determined using appropriate decay equations or tables. Packages must be weighed to enable calculation of final concentration.

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 five years.

9. Mixed Waste

The UW currently does not have cost effective 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 without acknowledgement of the potential costs associated with the disposal of the mixed waste.

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 RS at radsaf@uw.edu or 206-543-0463 to assist in researching questions concerning this issue.

Hazardous waste disposal must be consistent with the UW Hazardous Waste Program. Call 206-685-5835 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 contact UW Recycling for disposal guidance.

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 RS staff for disposal.

B. RECORDS AND LABELING

The UW's radioactive materials license requires continuous documentation of the UW radioactive material inventory and control on all aspects of work with radioactive materials. The specific retention requirements for radiation protection records which must be maintained by RUA holders is provided on the General Records Retention Schedule for Environmental Health and Safety and Facilities available on the UW Records Management Services website at https://finance.uw.edu/recmgt/gs/ehs?combine=Radiation&title=.

1. Waste Disposal Records

a. Radioactive Material Delivery and Usage Record (Form 160)

Form 160 is provided with each shipment of radioactive material. Indicating the disposal methods of the radionuclide on Form 160 and returning it to RS reduces your inventory. The RUA holder should retain copies of these records, for at least five 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 RUA holder should maintain a log for each mode of disposal.

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 the RSO Form 160 or in the Environmental Health and Safety Assistant (EHSA). When the package of waste is ready for transfer to RS, totals from Form 160 must be included with the package. Form 160 should remain in laboratory records.

2) Sewer

Disposal of soluble or dispersible radioactive materials into the sink must be recorded on the RSO Form 170 or in the Environmental Health and Safety Assistant (EHSA) on the EH&S website.

3) Atmospheric Release

The release of radioactive material to the atmosphere must be recorded on the RSO Form 160 or in the Environmental Health and Safety Assistant (EHSA) on the EH&S website.

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:

- RUA holder's name
- Phone #
- Budget #
- Mailbox #
- Radionuclide(s)
- Total activity of each radionuclide
- Laboratory of origin
- RAM tape or label (refer to 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 must be secured at all times and **must 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. Contact RS at radsaf@uw.edu or 206-543-0463 for current waste disposal costs.

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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 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

Individuals possessing sealed sources must apply for a Radiation Use Authorization (RUA) for sealed source use from Radiation Safety (RS). Refer to SECTION 4 – RADIATION USE AUTHORIZATION PROCESSfor application instructions.

1. Newly Acquired Sealed Sources

The purchase of sealed sources is controlled as described previously in 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 RS, Box 357165 or scanned to radsaf@uw.edu, 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 RS 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 RS to arrange for the move.

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 RS prior to that transfer.

a. Another UW RUA holder

Contact RS to transfer to another UW RUA holder.

b. Non-UW User

Contact RS to transfer sources to a non-UW entity.

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 RUA application procedures are described in SECTION 4 – RADIATION USE 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 every six months. . Sealed source leak tests and inventories are conducted by RS.

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. Results are documented and are available 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. RS staff take wipe tests only on adjacent surfaces and are careful not to 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 RUA for Sealed Source Use from RS.

1. Work Planning

The contractor conducting the work must submit the following to RS 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 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

RS 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 UW 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, RS will issue a RUA for Sealed Source Use signed by the RSO.

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 RUA 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 official.

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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, loses 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.

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 each 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 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 radiation. The device contains a G-M tube, which produces a voltage pulse whenever an ionizing radiation event interacts with gases 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.

Radiation Use Authorization (RUA) - Individuals are authorized to use radioactive materials via a Radiation Use Authorization (RUA) issued by the Radiation Safety Committee (RSC). The RUA defines specific conditions of radioactive material use and is an extension of the University's radioactive materials license.

RUA Holder - RUAs are issued to individuals who are affiliated with the UW to operate under the UW Radioactive Materials License of Broad Scope; these individuals are called RUA holders. An RUA Holder directs and supervises a project and is responsible for the coordination and management of the radiation protection program requirements for work performed under the RUA.

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 each 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, refer to "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. This template applies to all safety manuals EH&S has ownership and authority to create and update.

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