8-2-2019

Radiation Safety Program

University of Maine System

University of Maine
Radiation Safety Program

Program Scope

University of Maine intends to manage the Radiation Safety Program in a manner that ensures the most beneficial and responsible use of radioactive material for the purposes of research, education, and public service. The Radiation Safety Program is designed and administered to ensure that all radioactive material is acquired, used, disposed, and accounted for according to all applicable local, state and federal law.

Background and Purpose

Researchers, educators and students have the opportunity to use radioactive material or radiation producing equipment at the University of Maine. Electron microscopes, X-ray machines, sealed sources, detectors and tracers are in common use. Each category presents unique safety, environmental and regulatory concerns. The purpose of this document is to outline and address those concerns. There will always be four aspects to any Radiation Safety Program:

1. Written program
2. Training and Education
3. Documentation and Recordkeeping
4. Periodic review

The University of Maine holds two radioactive material licenses: A Broad Scope License and a Special Nuclear Materials License from the State of Maine.

All operations involving radioactive material or radiation producing equipment are governed by the following regulations:

- State of Maine Rules Relating Radiation Protection (SMRRRP)
- Code of Federal Regulations 10 Parts 19, 20, 30 - 33 and 71 (USNRC)
- Code of Federal Regulations 49 Parts 170 to 178 (USDOT)
- Code of Federal Regulations 29 Part 1910.1096 (OSHA)

The University of Maine Radiation Safety Program Organization

The University of Maine Radiation Safety Program is based on shared governance and cooperation between the UMaine Radiation Safety Officer (RSO), Safety Management, and the UMaine Radiation Safety Committee (RSC) and the administration of UMaine including the UMaine President, Chief Business Officer, and Vice President for Research.

The UMaine RSO has delegated authority from the UMaine President for the oversight of radiation safety for UMaine, its associated locations, including the Darling Marine Center, the Technical Research Center (TRC) in Old Town, and any associated remote sites. The UMaine RSO is a non-voting ex-officio member of the UMaine Radiation Safety Committee (RSC). The UMaine RSC has

members representing all uses of ionizing and non-ionizing radiation at UMaine and reports directly to the UMaine Vice President for Research. The UMaine Vice President for Research is a non-voting *ex-officio* member of the UMaine RSC.

The UMaine RSO provides reports, statuses, information, and other programmatic information to the UMaine RSC on a quarterly basis. Additionally, the UMaine RSC can be convened by any member, including the RSO, to address issues that may be of concern. The UMaine RSC acting as it sees fit regarding radiation program issues may elevate concerns directly to the UMaine President through the Vice President for Research.

The UMaine RSO, through their affiliation with Safety Management (SM), may formally request financial or administrative actions through the Director of Safety Management, as needed, to support the UMaine Radiation Safety Program. Examples of financial actions supported include budgeting and allocation of funds for training, recordkeeping, auditing, qualified expert inspections, dosimetry programs, instrument calibration, licensing and fees, and waste handling and disposal.

The Director of Safety Management makes these requests through the appropriate reporting lines.

University Of Maine Approval

The University of Maine's Radiation Safety Program, as outlined, has been prepared to comply with the State of Maine Rules Relating Radiation Protection (SMRRRP), Code of Federal Regulations 10 Parts 19, 20, 30 - 33 and 71 (USNRC), Code of Federal Regulations 49 Parts 170 to 178 (USDOT), and Occupational Safety and Health Administration's (OSHA) 29 CFR 1910.1096 Ionizing Radiation regulation. This program establishes that all university personnel shall have the right-to-know information about the properties and potential safety and health hazards of radiation that they may be exposed to in the course of their work.

This program has been reviewed and approved by:

Joan Ferrini-Mundy Date: 8/21/19
Dr. Joan Ferrini-Mundy, President, University of Maine

Date: 8/16/19
Dr. Kody Varahramyan, Vice President for Research, University of Maine

Claire Strickland Date: 8-15-19
Claire Strickland, Chief Business Officer, University of Maine

Dr C.T. Hess Date: 8/15/19
Dr. Charles T. Hess, Chairperson, Radiation Safety Committee, University of Maine

Date: 8/13/19
Michael D. Sauda, MPH, CSP, Radiation Safety Officer

Date: 8/13/19
Jeremy Sales, MS, Director of Safety Management

Peter Snow Date: 8-13-2019
Peter Snow, CHMM, Hazardous Waste Manager

TABLE OF CONTENTS

1 Responsibilities

1.1 University of Maine President

Ensures that an adequate Radiation Safety Program is developed, implemented, and maintained. This is accomplished through the delegation of responsibility and authority through the Vice President for Research, Office of Research Compliance, the Radiation Safety Committee, the designated Radiation Safety Officer, individual authorized users, and individuals under the supervision of authorized users.

1.2 University of Maine Vice President for Research

- Ensures that the University of Maine adopts and implements adequate administrative controls pertaining to the safe acquisition, use and disposition of isotopes and radiation producing equipment.
- Reviews, approves, and supports (where appropriate) the requirements of Safety Management policies and programs recommended and supported by the Radiation Safety Committee.
- Ensures Safety Management provides administrative and budget support for maintaining the integrity of the policies and programs.
- Provides assistance and support to Safety Management and the Radiation Safety Officer so as to ensure the enforcement of approved policies and programs.
- Supports and advocates compliance with Radiation Safety Program, Safety Management policies and federal and state requirements.
- Appoints personnel and granting authority to implement policies and programs, as needed.

1.3 Radiation Safety Committee (RSC)

The Radiation Safety Committee meets quarterly, when necessary. Each member has the right to convene the entire committee. The Committee consists of at least five faculty members with professional expertise in radiological issues, nominated by the Faculty Senate and approved by UMaine President. At least two members should have experience with radiation (ionizing and non-ionizing) producing equipment. One member should have expertise in laser issues/equipment. One voting member will be nominated by the Vice President for Research and approved by the UMaine President to help ensure a balanced mix of individuals on the committee.

The Radiation Safety Officer and the UMaine Vice President for Research(or designee) are *ex officio* non-voting members. The Chair is nominated and approved by a simple majority. In the event of disagreement among committee members, minority and majority reports are encouraged.

Radiation Safety Committee:

- Advises UMaine and Safety Management Administration on all radiological and regulatory issues associated with the Program.
- Evaluates and approves or disapproves all applications for "Authorized User" of radioisotopes or radiation producing equipment.

- Evaluates the Radiation Safety Program on an annual basis, and forwards findings to the Vice President for Research, as necessary.
- Investigates all instances of unsafe conditions or practices.
- Reviews laboratory inspection results, and producing corrective recommendations, when appropriate.
- Investigates all instances of regulatory non-compliance and provides corrective or remedial recommendations, when appropriate.
- Reviews the Radiation Safety Officer's reports and forwarding reports (with any corrections, revisions, or recommendations) to the Vice President for Research, as necessary.
- Evaluates significant radiological issues and developing recommendations for the administration.

1.4 Radiation Safety Officer (RSO) is responsible for:

- Radioactive Materials License amendment and renewal, annual review of the written Radiation Safety Program and the implementation status. Anticipates expansion of new regulations and addresses programmatic impacts on faculty, staff, students, and their respective projects and programs.
- Administers the University of Maine's Radiation Safety Program and ensures that the Maine Department of Human Services, Division of Health Engineering Radiation Control Program standards are established and observed.
- Radiation Monitoring/Dosimetry Program: Ensures distribution and collection of radiation dosimetry badges and rings
- Personnel exposure records
- Monthly/Quarterly notification of dosimetry results
- Semi-annual summary of exposure records
- Coordination with Human Resources Department/occupational health vendor for Medical Monitoring
- Coordinates and oversees the implementation of the campus radioactive waste program in consultation with the UMaine Hazardous Waste Manager.
- Surveillance and Inspections.
    - Annual Inspections of All Radiation Producing Areas - Ensures that all required semi-annual leak tests are performed and documented.
    - Conducts inspections of all non-exempt radiation producing areas, both on-campus and at remote sites.
    - Unannounced surveys of Specific Radiation Producing Areas
    - Audits of laboratory procedures
    - Ensures that annual calibrations of all radiation meters are conducted and appropriately documented.
    - Oversees scheduled sampling and reporting for the Greenbush Waste Site.
    - Develops, implements and maintains the central filing and record keeping system for all surveys, tests and procedures.
- Semi-Annual Inventory of:
    - Radiation Materials Management Areas
    - Areas with actual or potential disposals to sanitary sewer systems

    - Sealed sources
    - Radiation producing machines
    - Radiation Materials - Maintaining a current inventory of radiation producing substances and any equipment used at the University of Maine. This inventory is to include radionuclides, X-ray machines, electron microscopes, sealed sources and general license devices.
- Completes and files annual radiation waste reports.
- Campus Response or Consultation
    - Personal Protective Equipment
    - Engineering and administrative controls
    - Day to day operation of the Radiation Safety Program and advises the Radiation Safety Committee.
    - Facilitates involvement in the overall safety program of the Radiation Safety Committee.
    - Informs users of radioactive materials of applicable State and Federal regulations.
    - Informs the UMS Director of Safety Management regularly of relevant radiation safety problems and issues.
- Campus Radiation Safety Training Program
    - Assists in training laboratory personnel and others working with or coming into contact with radioactive substances in the course of their employment.
    - Training program development
    - Annual evaluation and revision
    - Recordkeeping and Retention - Establish adequate documentation guidelines and procedures to verify training and retains appropriate records.
- Notification Procedures
    - Regulatory Notification
    - Campus notification (Public Safety, Emergency Response Coordinator)
    - Action Level Reporting
- Controls and manages radiological issues at remote sites (e.g. the Darling Center, FBRI TRC).
- Develops and coordinates safety programs relating to radioactive materials. Specifies reasonable and adequate safety policies based on RSC input, State and Federal regulations and official regulatory guides.
- Ensures compliance with all applicable Federal and State regulations addressing the acquisition, use and disposal requirements related to research employing radioactive material at the University of Maine.
- Writes all required policies and standard operating procedures per agreement with the Greenbush Site Committee.

1.5 UMaine Facilities Management:

- Assists the RSO in all physical aspects of radiation locations on campus with respect to building descriptions, ventilation, plumbing, and any other infrastructure support.
- Adheres to RSO advice, training and support with respect to safe FM operating procedures when maintaining and/or renovating locations where radiation is either stored or used.

1.6 Strategic Procurement and Chief Procurement Officer are responsible for:

The acquisition, through established procedures, of all radioactive material and machines capable of producing ionizing radiation. The purchasing agent is assisted by the RSO in determining that the person ordering radioactive material is authorized and approved by the RSC to possess such material or device.

1.7 Managers, Supervisors, and Authorized Users

Authorized users include principal investigators and supervisors who have been formally approved for the acquisition and use of radioisotopes or radiation producing equipment by the University. The Authorized User assumes ultimate responsibility for radiological safety and regulatory compliance for all areas, materials and individuals under their control or supervision. Failure to maintain adequate safety and regulatory policies, procedures and records will result in suspension of radiation use privileges. Specific Authorized Users:

- Regularly inspect their areas for contamination and maintains appropriate records.
- Ensure that radioactive materials in their possession are properly secured against unauthorized removal when not in use.
- Ensure that the use of radiation by persons under their supervision is in accordance with NRC, RCP and RSC regulations.
- Ensure that they, and all individuals under their supervision (when appropriate), wear personal monitoring devices.
- Maintain an accurate inventory of the identity, quantity and location of all radioactive materials and radiation producing machines in their possession.
- Correct violations or unsafe situations which occur in areas or among individuals subject to the Authorized User's control. *Note:* **Failure to correct violations or repeat violations may lead to suspension or revocation of radiation use privileges.**
- Train all persons using radiation to follow the safety procedures and regulations listed in this document and maintain appropriate records.
- Use only those isotopes (and quantities), sources and radiation producing equipment approved by the RSC.
- Performs or causes to be performed routine contamination surveys and maintaining appropriate records.
- Ensure that all personnel are registered with the RSO prior to working with radiation. Notify the RSO when any individual terminates work at the University of Maine.
- Notify the RSO when planning to use new space for radioactive work or when laboratory space is no longer used for radioactive work.
- Provide suitable radiation detection instruments (survey instruments). These detectors must be calibrated annually and must be in good working order.
- Provide adequate shielding and other personal protective equipment.
- Provide for disposal of all radioactive waste prior to termination of employment at the University of Maine.
- Use radiation only for non-human applications (except Cutler Health and the Dental Clinic).
- Notify the RSO of any transfer of radioactive material to another University of Maine location.

- Notify the RSO of any planned shipment of radioactive material via a common carrier. The RSO must approve any such shipment.
- Remediate and document any contamination > 50 DPM above background. The RSO will advise and assist with any contamination problems.
- Maintain records including names and contact information of individuals working with radiation, used in the laboratory issues. For example:
    - Working rules and laboratory policy
    - Use of survey meters or other detection equipment
    - Proper handling and dilution techniques
    - Proper use of personal protective equipment
    - Proper use of engineering controls
    - Proper spill clean-up methods and materials
    - Proper storage and labeling of radioactive materials
    - Standard (protocol and isotope specific) operating procedures

1.8 University of Maine Employees and Students:

- Registers with the RSO as a Radiation Worker.
- Reads, understands and follows this manual
- Diligently follows all instructions and operating procedures.
- Attends all required training sessions.

2 Radiation Safety: General Considerations

As radiation is not visible, a number of different but related approaches must be taken to ensure human health and protection of the environment. These approaches are described below, and in more detail in subsequent sections.

These procedures apply to all individuals, departments, and locations at the University of Maine (including remote sites) that receive, possess, use, transport, or dispose of radioactive material.

2.1 Authorized Users - Conditions for Licensing and Registration

Individuals wishing to be approved for the acquisition and use of non-exempt radioactive material must apply to the Radiation Safety Committee (see Appendix A - Authorized Isotope User Application). This application must be approved whether the materials are procured by purchase, inheritance, loan, or gift.

The applicant must directly supervise the project involving radioactivity, and is responsible for its safe conduct within the parameters set by the authorizing application, the requirements of this manual and regulations 10 CFR Parts 20, 30-33 and the State of Maine Rules Relating to Radiation Protection (SMRRRP) Sections C, D and N.

Any Authorized User found to be willfully or negligently violating University, NRC or State regulation governing the use of radioactivity may have approval revoked or suspended. The RSO has the University Administration's authority to immediately stop any operation posing an immediate threat to human health or the environment.

The RSC has adopted the following guidelines for addressing problems that may arise in radiation areas:

- The RSO investigates and reports findings to the RSC.
- The RSC investigates further and forwards recommendations to the Vice President for Research
- The Administration takes the action necessary to correct the problem and reports such action to the RSC.

2.1.1 Temporary Inactive Status of an Authorized User Laboratory

An Authorized User may choose to temporarily transition their laboratory into an "Inactive" status during anticipated periods when no radioactive material will be received, possessed, used, transported, or disposed (suggested minimum, six months). During "Inactive" status the following radiation safety requirements will be suspended:

- Mandatory Laboratory Security
- Dosimeter Receipt and Exchange
- Inspection Questionnaire Responses
- Survey Meter Calibration

NOTE: In order to maintain "Authorized User" status the individual must ensure that all required radiation safety training is current as noted in this program. Failure to maintain training will result in revocation of "Authorized User" status and will require re-application as outlined within.

An Authorized User may change their laboratory to "Inactive" status simply by notifying the Radiation Safety Officer (RSO). Returning to "Active" status can be accomplished within 1-2 days by:

- Notifying The RSO
- Maintaining Laboratory Security
- Receiving Dosimeters, As Required
- Receiving Survey Equipment (Loaners are immediately available, while awaiting calibration of the AU's meter ~ two weeks.)

Authorized Users that do not receive, possess, use, transport, or dispose of radioactive material for periods exceeding 12 months will automatically have their laboratory placed in temporary "Inactive" status.

2.2 Engineering Controls: First Line of Defense and Recommended Course of Action

Engineering controls include shielding, authorized fume hoods, interlocks, etc. Do not perform any radiological task with inadequate or malfunctioning engineering controls. Even with proper shielding, any effective dose can be diminished by minimizing the time of exposure.

2.3 Administrative Controls - Second Line of Defense and Recommended Course of Action

Administrative controls include policies such as material security, the prohibition of eating, drinking or smoking and use of hand held devices such as mobile phones, in restricted areas, training and experience requirements, audits and periodic review.

2.3.1 Security of Radioactive Material

All radioactive material MUST be secured from unauthorized use, removal, tampering, and vandalism at all times. Unsecured radioactive materials must NEVER be stored or used in an unrestricted and un-posted room, area or facility. Unsecured material MUST never be left unattended. Restrict radioactive material access from anyone not authorized to use those materials under your UM-issued Authorization to Use Radioactive Materials. If someone seems suspiciously interested in the materials, there location or appears to be making observations or plans to acquire the materials without authorization, contact UMPD. If you see something, say something.

2.3.2 Caution Signs and Labels

Every campus location storing or handling radioactivity or radiation producing equipment will be posted with appropriate signage per 10 CFR Parts 19.11 and 20.1901-1905, and SMRRRP Sections D.27-31 and J.2.

2.3.2.1 Radioactive Material Areas:

- Each area will be posted with the "Notice to Workers" Contact RSO for notice which will be provided
- Each container of radioactive material will be clearly labeled with the conventional radiation symbol, the words "Caution Radioactive Material", the identity and activity of the isotope, and the date.
- Each area will post the appropriate emergency phone number and emergency contacts.
- Each restricted area shall be labeled as such, including the words "Caution Radioactive Material: NO eating, drinking or smoking.
- All radiation work areas in restricted areas will be clearly defined. All work in these areas requires the use of personal protective equipment, badges (when deemed appropriate by RSO), etc.
- The RSO will provide the appropriate signage for lasers, X-ray machines, and electron microscopes.
- All radioactive material storage areas (refrigerators, cabinets, etc.), must be labeled as such: "Caution Radioactive Materials".

Note: Radiation labeling is not required for typical laboratory containers (flasks, beakers, eppendorf tubes) when used transiently in the user's presence.

2.3.2.2 Radiation Producing Machines

All radiation producing machines and areas must be secured against unauthorized use and properly posted. Contact the RSO for signs and labels which will be provided.

2.3.3 Incident Preparedness

Each radiation worker must be prepared to cope with incidental spills or accidents. This preparation must include the presence of adequate clean-up materials and training in their use. Each Authorized User must provide the material necessary to remediate any incidental spill occurring in their area. This typically involves protective equipment, an absorbent, and disposal bags coupled with adequate cleaning materials. The RSO is available to assist with major spills.

2.3.4 Personal Protective Equipment (PPE)

Personal protective equipment includes disposable gloves, lab coats, tongs, etc. Gloves and protective clothing must be worn whenever working with radioactive material (other than some sealed sources).

2.3.5 Employee Notification

Each radiation area will be posted with a "Notice to Employees" bulletin as required by the State of Maine Standards for Protection Against Radiation.

2.3.6 Eating and Drinking Policy

Eating, drinking and smoking are not allowed in restricted areas. Application of cosmetics is also not allowed in restricted areas. Evidence of eating, drinking, smoking, or cosmetics is not allowed in restricted areas. Failure to abide by this policy may result in suspension or termination of isotope privileges. Coffee cups, soda cans, food wrappers in a trash can, all constitute evidence of infraction. Gum chewing, using cough drops or placing one's pen in their mouth are examples of infraction.

2.3.7 Training and Education

All aspects of the Radiation Safety Program must be understood and diligently followed by all radiation workers. This education must include not only this manual, but the biological effect of radiation, general radiation principles, engineering controls, personal protective equipment, monitoring and surveillance, specific experimental procedures, record keeping, disposal methods, and general regulatory information.

This education is accomplished by scheduled training sessions by the RSO, training in specific procedures by the Authorized Users and reading printed material. Training and instruction is an annual requirement for continued radiological work at the University of Maine. Training and education are provided by the RSO and the Authorized User.

2.3.8 Reallocated Equipment

Reallocated equipment must be decontaminated prior to removal from the restricted area.

2.4 Radiation Monitoring Instruments

2.4.1 Radiation Monitoring Equipment Selection

The RSC or RSO, as appropriate, will review and approve radiation monitoring instrumentation based on the following criteria to assure that it will be appropriate during licensed activities. The RSC may decide in its review of technology or appropriate instrument calibration that selection criteria or calibration practices require adjustment based on accepted health physics practices or standards. Following such RSC decisions results/requirements will be published in the radiation safety manual.

Portable Instrument Selection Criteria for Contamination and Ambient Radiation Surveys			
Detectors	**Radiation**	**Energy Range**	**Efficiency**
GM	Alpha	All energies (dependent on window thickness)	Moderate
	Beta	All energies (dependent on window thickness)	Moderate
	Gamma	All energies	< 1%
NaI Scintillator	Gamma	All energies (dependent on crystal thickness)	Moderate

Stationary Instrument Selection Criteria Used to Measure Wipe, Bioassay, and Effluent Samples			
Detectors	**Radiation**	**Energy Range**	**Efficiency**
Liquid Scintillation Counter	Alpha	All energies	High
	Beta	All energies	High
	Gamma		Moderate
Gamma Counter (NaI)	Gamma	All energies	High
Gas Proportional	Alpha	All energies	High
	Beta	All energies	Moderate
	Gamma	All energies	< 1%

2.4.2 Equipment Calibration

Survey instruments used to determine compliance with regulatory requirements will be calibrated periodically by the instrument manufacturer or persons specifically authorized by NRC or an Agreement State. Survey instruments will be calibrated at least annually (every 12 months), unless otherwise specified by regulation or license condition.

2.5 Personal Protective Equipment

2.5.1 Selection and Use of Equipment

Personal protective equipment includes disposable gloves, lab coats, tongs, etc.

2.5.2 Gloves

Gloves must be worn whenever working with radioactive material (other than some sealed sources).

2.5.3 Clothing

Individuals working with radioactive material are required to wear protective garments to prevent contamination of the body or street clothes. The typical lab coat is considered a minimum fulfillment of this requirement. Additional protective equipment or garments, commensurate with the potential hazard, may be required as determined by the RSO.

2.5.4 Respiratory Protection

No respiratory protection may be used without prior RSO authorization and consultation with Safety Management.

2.5.5 Personal Protective Clothing Monitoring

Care and maintenance of lab coats is the responsibility of the owner.

2.5.6 Purchase and Replacement

The Authorized User will provide lab coats for staff. Students are generally required to purchase their own. All other PPE is provided by the Authorized User (gloves, vests, etc.).

2.6 Laboratory Surveillance

Regular surveys for radioactive contamination are an essential element of the Radiation Safety Program. Contamination can be present on (or in) instruments, on floors, bench tops, door knobs and ventilating systems. Such contamination must be located, identified, quantified and remedied. These procedures are necessary to limit both internal and external dose.

For the purpose of this section, the term surveillance means the observation of radiological conditions in restricted areas by the person who performs the routine radiation and contamination surveys. This surveillance is one of the more important aspects of any radiation safety program.

Through organized, periodic and scheduled surveillance personnel acquire the detailed knowledge necessary to: 1) identify ways of preventing or minimizing occupational exposure; 2) select appropriate times for performing radiation safety measurements; and, 3) to adequately prepare for emergency conditions.

The surveillance program should include the following:

- Regular inventory of radioactive material, including identity, location and disposition
- Frequent audits of radiation safety procedures (an agenda point at each lab meeting, for example)
- Comparison of the amount of material in use with possession limits
- Discussion with personnel to ensure continued awareness of safety procedures and adequacy of training and instruction

- Evaluation of the adequacy of existing engineering controls
- Evaluation of spill or incident response equipment and materials
- Evaluation of procedural changes.

Monitoring and surveillance mean actual tests for the presence of radiation in an area in addition to dosimetry and continually evaluating the operation of the Radiation Safety Program as a whole. These activities take the form of wipe tests, surveys, dosimetry badges, inspections, audits and periodic review. Monitoring and surveillance methods and schedules are detailed within.

2.6.1 Survey Schedules

Each laboratory must perform and record contamination surveys weekly when isotopes are in use. In addition, surveys must be performed immediately following use of one millicurie or more.

When isotopes are not in use for a period of one week or longer, surveys need not be performed. The statement "No isotopes in use (date)," must be entered in the survey log book.

Although survey records must be retained by the Authorized User for three years, the RSC recommends permanent retention. Each registered, active (having isotope usage: receipts, use or waste during a quarter) performance area will be inspected quarterly.

The RSO will (periodically) perform random confirmatory contamination surveys during scheduled and unscheduled inspections.

2.6.2 Survey Areas

Equipment Survey:

Prior to the transfer of potentially contaminated equipment or instruments from a restricted to unrestricted area, surface contamination surveys must be conducted, and records maintained.

The Authorized User is responsible for performing, or causing such surveys to be performed, and maintaining accurate records. Some examples include the transfer of a microfuge from a hot lab to an undergraduate teaching lab, or the transfer of a scalpel from a hot lab to a greenhouse or hatchery.

Sealed Sources:

Non-exempt sealed sources shall be wipe tested by the RSO. Sensitivity of the assays will be such that activities equal to 5 nanocuries can be detected. Activities greater than 5 nanocuries will result in the decontamination and return to the manufacturer of the source. A report of such contamination will be sent within five days to the SMRRRP. The RSO shall develop and maintain a complete inventory of all non-exempt sealed sources.

- For non-exempt, beta or photon emitting sealed sources, six-month wipe (leak) tests are required.
- For non-exempt, alpha emitting sealed sources, 3 month wipe (leak) tests are required.

2.6.3 Survey Methods, Procedures and Audits

2.6.3.1 Removable Contamination

Removable contamination means radioactivity that can be transferred from a surface to wipe test paper or to cleaning implements. Methods and instruments used in surface contamination surveys should be sensitive enough to detect the nuclides being monitored. For low energy beta (C-14, H-3), alpha, and low energy gamma and X-ray emitters, liquid scintillation or gamma counting is required.

The preparation of wipe-tests may be preceded by an initial survey with a thin-end-window detector in order to:

- Ensure that contamination levels are safe for wipe-testing,
- Diminish the chances for inadvertent spreading of the contamination, and
- To determine those areas requiring greater attention for wipe-testing.

Wipe-test records must include the following information:

- Contamination levels in DPM (requires instrument calibration),
- Make and model number of the survey instrument,
- Sample and background counts, counting time, and windows,
- Signature and date.

2.6.3.2 Standard Method for Wipe Tests:

- Use filter paper or cotton swabs, dampened with 70 percent ethanol or de-ionized water.
- Wipe an area of 100 square centimeters, if possible.
- Prepare a blank.
- For beta emitters, use a calibrated liquid scintillation counter (LSC).
- For gamma emitters, use a calibrated gamma counter or LSC.
- Convert CPM to DPM via an efficiency calculation.
- Sign and date the printout, or record results in the wipe test log book.
- Any result greater than 50 DPM above background requires decontamination followed by confirmatory wipe tests.

2.6.3.3 Sealed Sources Wipe Tests

Sealed sources shall be wipe tested in the following manner: filter paper or cotton swab, dampened with ethanol (70%) or de-ionized water and held by forceps or swab handle, will be wiped over the source or the closest accessible surface, according to manufacturer instructions.

2.6.3.4 Fixed Contamination

Fixed contamination is radioactivity remaining on a surface despite repeated decontamination efforts. This situation arises periodically and typically involves complex instrumentation (i.e. centrifuges), floor spills or plumbing. All cases of fixed contamination shall be reported to the RSO. Depending on the nature of the contamination, removal and disposal of the affected material may

be warranted (such as pipes or floor tiles). For short half-life contamination, labeling and shielding for ten half-lives may be adequate. Proper remediation for all fixed contamination shall be determined by the RSO.

2.6.3.5 Action Levels

Whenever a survey or wipe test indicates contamination levels greater than 50 DPM (above the blank) on surfaces or equipment, decontamination action shall be initiated. The original contamination and final resolution shall be entered in the survey logbook. Unsuccessful decontamination efforts shall be referred to the RSO.

2.6.4 Special Monitoring Requirements/Bioassays

At present, bioassay is not a requirement of our license. Consider specifying free I-125 conditions for bioassay.

2.6.5 Work Site Surveys

2.6.5.1 Performance Area Inspection Schedules (RSO):

- Schedule One: **Annual Inspections**
  - General License Materials

- Schedule Two: **Semiannual Inspections**
  - Laboratories using sealed source materials
  - Electron microscopes
  - X-ray producing equipment
  - Radioactive Waste Site

- Schedule Three: **Quarterly Inspections**
  - Laboratories actively using unsealed radioactive materials.

- Schedule Four: **Quarterly and Unannounced Inspections**
  - Laboratories actively using radioactive materials, history of repeated violations, or repeated relatively high exposure.

2.6.6 Ventilation Monitoring

Fume hoods will be inspected annually by Safety Management. The minimum acceptable face velocity for a fume hood with sash in the operating position is 100 feet per minute at a sash height of a least 15 inches. Regular confirmation of hood flow and direction should occur prior to any use.

2.6.7 Ingestion and Inhalation

The Radiation Safety Program addresses the issue of internal dose by including firm policy and procedural language designed to eliminate any opportunity for isotope ingestion. (See Eating and Drinking Policy under Administrative Controls)

In addition, water fountains, food areas, coffee machines, mobile phones located or used near areas where radioactive material is used or stored should be periodically wipe-tested.

Inhalation of airborne radioactive materials is controlled through mechanical ventilation and experimental protocol. When fume hoods are necessary to protect workers from unsealed radioactive sources, face velocity measurements shall be performed annually.

2.7 Personal Monitoring

The University of Maine has implemented a personal monitoring program for staff, students and visitors to monitor and record external occupational exposure to radiation as required in *State of Maine Rules Relating to Radiation Protection*, D.18.

2.7.1 External Monitoring

Monitoring of external radiation exposure is required for the following individuals:

- Persons using high energy beta emitting radioisotopes (> 250 keV),
- Persons using neutron sources (thermal, intermediate and fast)
- Persons using open beam gamma, X-ray and X-ray producing equipment.

Area monitoring only, is required for all interlocked, closed-beam analytical x-ray instruments (radioactive material source or equipment producing).

Individuals working solely with Cr-51, S-35, P-33, C-14 or H-3 are not required to wear external monitors.

Optional Monitoring

External monitoring can be requested by any person working in a laboratory in which x-ray, gamma emitters or energetic beta emitters are used, even if that person does not meet the criteria for required monitoring.

In such a case, the RSO will meet with the worker initially to discuss any concerns the worker has and will then initiate radiation monitoring for the next year. After providing dosimetry for a year, the RSO will meet with the worker again to review doses for the past year and to discuss whether monitoring should be continued.

Monitoring is not generally provided for persons working in laboratories in which only alpha emitters or low energy beta emitters (< 250 keV) are used.

External Monitor Badge Rules:

- Badges must be worn at all times when working with ionizing radiation.
- Whole body exposure badges must be worn between the neck and the waist line.
- Wear badges so the name label faces toward the source of radiation.
- Wear ring badges on the hand receiving the greater exposure and under gloves to avoid contaminating the badge

- Badges should be worn beneath any lead aprons.
- Notify the RSO immediately if you suspect you may have received an unusual exposure.
- Do not wear badges when you receive medical x-rays or are exposed to other medical sources of radiation.
- If your badges become contaminated, damaged or lost, call the RSO immediately to request replacements.
- Badges are generally exchanged once a quarter, although badges for declared pregnant workers are exchanged once a month.
- Return badges to the central storage location (away from all sources of radiation) promptly at the end of each use to avoid losses/inadvertent monitoring termination.
- Do not take badges home or out of the workplace.
- Badges should not be tested, run through security checks, stored in vehicles.

In addition to quantifying effective occupational dose, badges supply additional benefits:

- Alerting the RSO to equipment malfunction.
- Alerting the RSO to isotope mishandling or inadequate shielding.
- Providing an occupational exposure history for future employment requirements or health issues.

2.7.2 Program Management

The personal dosimetry program is managed by the RSO. The RSO maintains all records of occupational exposure.

The University of Maine Radiation Safety Program Action Level for the individual exposure is 10 percent of a quarterly applicable limit, as specified above (SMRRRP D.6.) Action includes a standard investigation report (see Appendix C). Findings and recommendations will be forwarded to the Authorized User, the exposed individual and the RSC.

2.7.3 Distribution of Devices

Badges are issued monthly or quarterly depending on application. Safety Management will collect used badges and distribute new ones at the first of each month or quarter (January 1, April 1, July 1, October 1) respectively. Authorized Users must make every effort to have badges available for collection on time. This generally means designating a central location where badges are kept.

2.7.4 Disposition of Devices

All monitoring badges will be sent to a NVLAP accredited laboratory for analysis with results reported directly to the RSO.

2.7.5 Occupational Dose Records and History

All program participants having prior workplace radiation exposure must assist the RSO in obtaining prior occupational exposure histories by completing Appendix C - Request for Previous Occupational Exposure

2.7.6 Access to Dose Records

Annual Occupational Exposure Records (USNRC Form 5) are forwarded to the authorized user for distribution to the individual badged user for respective annual exposures > one percent (1%) of SMRRRP D.6. Additionally, individual exposure records are available from the RSO upon request.

2.7.7 As Low As Reasonably Achievable (ALARA) Program

The University of Maine requires that all persons working with licensed radioactive materials **must** use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles in order to achieve occupational doses (internal and external) that are ALARA. In addition, the Radiation Safety Committee has adopted an ALARA Dose Level threshold of 10 percent of the State of Maine quarterly dose limits. Individuals at the UM who exceed these levels are contacted by the RSO to advise them that some additional effort will be needed to reduce individual doses. Safety Management tracks ALARA thresholds for all individuals issued dosimeters.

2.8 Medical Monitoring

Components of the medical monitoring program include provisions for previous exposure history, personnel dosimetry data, medical supervision subsequent to over exposure or personnel contamination, and work site conditions and procedures evaluation.

2.8.1 Monitoring for Over-exposure

Monitoring for over-exposure is accomplished by personal dosimeter badges or calculation.

2.8.2 Employee Notification

Employees are informed annually of personal dosimeter reports. Employees are informed of any monthly or quarterly over-exposure recorded by personal dosimeter badges. Current and cumulative exposure records are always available to the employee upon request.

Authorized Users are responsible for notifying the RSO of all additions to or deletions from the lists of personnel using radiation.

Employees requiring medical surveillance will be referred to the examining physician by the Office of Human Resources, based on information from the RSO.

2.8.3 Medical Follow-up

Employees will be subject to medical surveillance when the potential exposure to ionizing radiation is such that somatic biological effect, susceptible to medical detection, could occur to the individual. Appraisal shall include acute and chronic exposure evaluation and will consider such variables as source, duration, energy, chemical form, and type of exposure.

2.8.4 Access to Medical Records

Any employee may obtain a copy of his/her radiation directly from the Occupational Medicine provider.

2.8.5 Medical Records Requirements

Radiation test records will include:

- Name and job description of the employee
- Date of the test
- The examiner's name
- Employee's most recent radiation exposure assessment
- Prior exposure history and information of the employee

All radiation and medical records will be maintained for a period of 30 years after termination of employment.

Individual employee radiation and medical test results will be considered confidential, and will be released to another party only upon the signed consent of the employee. A form shall be used for this purpose.

Any employee may obtain a copy of his/her radiation evaluation and medical records upon written request to the Human Resources Department.

Radiation Safety Officer will coordinate with Human Resources Department for Medical Monitoring.

2.9 Maintenance and Renovation Activities in Radiation Areas

2.9.1 Laboratory Personnel Notification

Laboratory personnel must be notified prior to any maintenance or renovation activity in a restricted area.

2.9.2 Maintenance Personnel Notification

Maintenance personnel must be informed that the maintenance or renovation work will take place in a restricted area.

2.9.3 Janitorial/Custodial Personnel Notification

Custodians will be instructed annually with respect to health and safety issues present in restricted areas.

2.9.4 Supervisor Notification

Supervisors will be notified of any maintenance or renovation work taking place in a restricted area.

2.9.5 Clean-up Procedures for Maintenance Activities

Authorized Users are responsible for ensuring that all areas subject to maintenance or renovation are decontaminated to background levels prior to the beginning of such work. Examples include fume hoods, sinks/traps, bench tops, and floors.

3 Radioactive Material and Sealed Source Management

3.1 General

These procedures apply to all individuals, departments, and locations at the University of Maine (including remote sites) that receive, possess, use, transport, or dispose of radioactive material.

3.2 Exemptions

Some sources of radioactive material are exempt from State and Federal regulation. Examples include self-luminous radium dials, samples taken directly from the environment, and certain defined quantities of sealed and unsealed sources (SMRRRP C 2 and 3).

Individuals working with exempt substances do not need to be approved by the Radiation Safety Committee (RSC). Exempt users must follow all of the proper health and safety guidelines outlined in this manual, and inventory and dispose (of) all radioactive material accordingly. Exempt quantity radioactive isotopes are included in an annual isotope inventory. Individuals and laboratories using only exempt quantities of isotope may still be inspected by the Radiation Safety Officer.

3.3 Registration Requirements

3.3.1 Radiation Material Management Areas (RMMA's)

All campus locations where radioactive material is to be stored or handled must be registered with the RSO and approved for this use (see Appendix A - Authorized Isotope User Application and the Authorized Isotope User Approval).

3.3.2 Laboratory Workers

All individuals working with or near radioactive materials or radiation generating equipment who are likely to receive a dose in excess of 10 percent of the applicable levels listed in section 6.6.3 must register with the RSO. These individuals must receive a personal dosimeter, along with training and instruction on isotope use. Women working with exposure to radiation sources that are or may become pregnant are encouraged to notify the RSO in writing to declare the pregnancy.

3.3.3 Inventory

The RSO will inventory generally licensed devices annually, sealed sources and X-ray machines semi-annually and unsealed radioactive material quarterly. Authorized Users must always maintain an up to date, accurate inventory of all sealed sources, X-ray machines, and radioactive material (including identity, activity, and disposition). Inventory is listed under "Responsibilities: Authorized Users".

3.4 Procurement Procedures for Radioactive Materials and Sealed Sources

3.4.1 Ordering Materials

Only those individuals authorized by the RSC may order radioactive materials. The Authorized User is responsible for ensuring that only those isotopes and quantities allowed to be in his/her possession are ordered.

3.4.2 Receipt and Opening of Containers

Each incoming package of vendor purchased radioactive material will be shipped directly to the Radiation Safety Officer (RSO) in Safety Management. Reactive materials will then be released to authorized users and must be logged in when received. The date, isotope, and activity shall be recorded as part of the laboratory's inventory (see Appendix E - Isotope Receipt Form; or Radionuclide Receipt, Utilization, and Disposal Record form).

When receiving radioactive shipments, the following procedure must be carried out:

- Appropriate personal protective equipment must be worn (disposable gloves, lab coat, etc.)
- Radiation badges, if appropriate, must be worn.
- Measure the exposure rate from a distance of one meter, then at the package surface. If the exposure rate is higher than the values listed below, secure the package and notify the RSO.

Transportation Index	Exposure Rate (mR/h)	
	1 Meter	Surface
White I	Background	<0.5
Yellow II	1	50
Yellow III	10	200

- Remove and open the packing slip. Check this information against the user request form. If the material is not exactly what was ordered, contact the RSO for return instructions. Otherwise,
- Open the outer package, following the vendor's instructions, if provided. Visually inspect the package for damage. When applicable, is the dry ice still present? Is there evidence of leakage?
- Open the inner package and verify that the contents agree with the packing slip (isotope, activity, chemical form) and user request form.
- Perform wipe tests on the inner package and the final source container. Record the results. Contamination levels greater than 200 dpm/100 square cm must be reported to the RSO.
- Log the received material in the laboratory's inventory.
- Survey the packing material. If contaminated, handle as radioactive waste. If not, dispose of packing material in normal trash (obliterate any radiation symbols first).
- Secure the received material.

3.4.3 Signage Requirements

The RSO will determine signage requirements for all campus locations using or storing radiation or radiation producing equipment.

All rooms in which radioactive materials are used or stored shall be posted "Caution Radioactive Material".

All radiation producing machines and areas must be properly posted. Contact the RSO for signs and labels.

3.4.4 Disposition

The RSO must be notified of any intent to store, dispose, recycle, abandon, salvage for parts, or give away any radiation producing machines.

3.4.5 Recordkeeping

All radiological records shall use the SI units Becquerel (Bq), Gray (Gy), Sievert (Sv) and Coulomb per kilogram (C/kg), or the special units Curie (Ci), Rad, Rem, and Roentgen (R), including multiples and subdivisions, and clearly, legibly, and durably indicate the units of all quantities in records required by this section.

Each record required by this section shall be legible throughout the specified retention period. The record shall be the original, a reproduced copy, or stored in electronic format. Copies in electronic forms must be authenticated by authorized personnel. Adequate safeguards against tampering, loss and destruction shall be maintained.

3.5 Inventory

3.5.1 Radiation Materials Management Areas (RMMA)

The RSO will quarterly tabulate RMMA's. RMMA's are designated as such by the RSO. RMMA's may not be returned to unregulated use without a decommissioning report completed by the RSO.

3.5.2 Sealed Sources

The RSO will inventory sealed sources semi-annually.

3.5.3 Radiation Producing Machines

3.5.3.1 Inspections and Registration

All X-ray machines must be inspected by the RSO semi-annually. All non-exempt radiation producing machines must be registered with the State and inspected by a state registered "Qualified Expert" every two years, clinical and analytical x-ray machines are inspected every two years and veterinarian units every five years. Inspection records are maintained by the RSO.

3.6 Storage

3.6.1 Radioactive Materials Storage and Signage Requirements

The RSO will determine signage requirements for all campus locations using or storing radiation or radiation producing equipment. All rooms in which radioactive materials are used or stored shall be posted "Caution-Radioactive Material".

Radioactive material must be stored in such a manner that exposure to personnel is minimized. Suitable storage precautions shall prevent unauthorized removal or loss. In addition, precautions must be taken to prevent damage due fire, explosion, or flood. Radioactive material must be secured when not in use. All stored radioactive material must be adequately, durably and legibly labeled with respect to isotope, activity, date, and owner.

3.7 Radiation Producing Machines

3.7.1 Acquisition and Use

Individuals requiring radiation producing machines shall obtain approval from the Radiation Safety Committee prior to acquisition, whether by purchase, loan or gift.

3.7.2 Proposal for Use

The proposal for use must include the following information:

- Principal Investigator or Instructor, and the extent of experience with the particular instrument requested
- Names of other personnel who will use the equipment
- Description of the instrument, proposed use, and intended location
- Health and Safety measures provided, such as shielding, monitoring, inspection and training

3.7.3 Procedure Guides

The Principal Investigator shall provide the RSO an owner's manual for the instrument. Each individual operating the equipment shall be thoroughly familiar with the manual and all operating procedures.

3.7.4 Purchase/Acquisition

All purchases of radiation producing machines shall be made through the Purchasing Department upon certification by the RSO that the acquisition has been approved.

3.7.5 Survey of Installation

Prior to use, installations of radiation producing machines, whether newly acquired or relocated, shall be surveyed by the RSO in order to determine the effectiveness of shielding, interlocks, and other engineering controls.

3.7.6 Changes in Location

The RSO must approve, in advance, any relocation of a radiation producing instrument.

3.7.7 Disposition

The RSO must be notified of any intent to dispose, abandon, salvage for parts, or give away any radiation producing machine.

3.7.8 Caution Signs and Labels

All radiation producing machines and areas must be properly posted. Contact the RSO for signs and labels.

3.7.9 Personal Dosimetry Badges

All individuals working with or near operating open beam X-ray machines must wear personal dosimeter.

3.7.10 Lockout

Malfunctioning or improperly used radiation producing machines will be locked out by the RSO, pending Radiation Safety Committee concurrence.

4 Transportation of Radioactive Materials, Sealed Sources and Radiation Producing Equipment

With the exception of standard transfers of radioactive materials during the course of routine laboratory procedures, all transfers of radioactive materials within the University of Maine boundaries must conform to the following:

- All material shall be packaged in sealed, shatter-proof containers.
- All containers shall be properly, durably, and legibly labeled with respect to isotope, activity and date. This information shall also be recorded on the "Shipping Paper" (available from the RSO) whenever a vehicle is involved.
- The measured dose rate shall not exceed 10 mR/h at 1 meter, or 200 mR/h at the surface.

4.1 Transportation of Radioactive Materials on Campus

The routine transfer of isotopes from one approved lab to another approved lab for experimental purposes is not regulated by this manual. However, the same guidelines with respect to exposure, contamination of unrestricted areas, shielding, and safe radiological practices still apply. In addition, the transfer of all primary sources from one campus location to another shall be accomplished by the RSO.

Transporting isotopes from one location to another for experimental purposes should not be confused with transfer of ownership. Transfer of ownership requires RSO approval.

4.2 Transportation of Radioactive Materials to Off-campus or Satellite Locations

Contact the RSO for packaging, labeling, and transport requirements prior to shipping. The RSO must approve all such shipments and maintain all required records.

4.3 Waste Pick-up and Transport

The RSO will complete shipping papers for each container of radioactive waste transferred to the waste site. The Authorized User is responsible for attesting to the actual container contents. In addition, the Authorized User is responsible for assuring that there is no significant removable contamination on the outside of the container.

4.4 Recordkeeping

All radiological records shall use the SI units Becquerel (Bq), Gray (Gy), Sievert (Sv) and Coulomb per kilogram (C/kg), or the special units Curie (Ci), Rad, Rem, and Roentgen (R), including multiples and subdivisions, and clearly, legibly, and durably indicate the units of all quantities in records required by this section. Each record required by this section shall be legible throughout the specified retention period. The record shall be the original, a reproduced copy, or stored in electronic format. Copies in electronic forms must be authenticated by authorized personnel. Adequate safeguards against tampering, loss and destruction shall be maintained.

5 Radioactive Waste Management

The temporary radioactive waste storage site is located off the farm road northeast of Knox Hall, in the City of Old Town. The site consists of ten concrete storage rooms. Presently, rooms 6 and 8 are used to store radioactive waste. The remaining rooms are used to store chemical hazardous waste. There is also a laboratory equipped with a fume hood, eyewash, shower, radio, and telephone. A detailed description of the site is available in the University of Maine "Emergency Response Plan".

***Important note*:** The University of Maine discourages the production of mixed waste, i.e., waste that is both hazardous and radioactive. An example is toluene based LSC cocktail. Any procedure involving mixed waste must be approved by the RSO.

5.1 Disposal Procedures for Radioactive Materials, Sealed Sources and Radiation Producing Equipment

There are several distinct categories of radioactive waste produced at the University of Maine. Although each category is handled differently, all are subject to the same administrative controls.

5.1.1 Factory Return

All factory returns shall be accomplished by the RSO, who will also retain appropriate documentation.

5.1.2 Waste Minimization

Disposing of radioactive waste is an expensive national problem. In addition, the cost for sending our waste to an approved waste site is enormous. Even "store for decay" waste has become an issue, due to the physical limitations of our temporary storage site. For example, each bag of S-35 must be held for almost three years. Accordingly, the RSC urges all authorized isotope users to make the waste minimization perspective a routine part of all experimental design, execution, and training.

5.1.2.1 General Considerations:

- Evaluate equivalent non-isotopic options and methods. (DNA sequencing)
- Use cleanable, re-usable trays instead of absorbent bench paper.
- If something is not radioactive, do not dispose of it in the radioactive waste bag.
- Use water soluble scintillation cocktail.
- Evaluate past laboratory solid waste records.
- Document all waste minimization efforts.

5.1.3 Radiation Waste Pick-up and Transport Requests

Presently radioactive waste is collected from each laboratory when requested. The Authorized User must fill out the request form and forward it to the RSO (see Appendix G - Request for Radioactive Waste Pick-up).

5.1.4 Waste Categories and Segregation Requirements

Nearly all waste brought to the site is solid waste. Some mixed waste and a small amount of liquid waste stored for decay is present. The solid waste can be categorized as follows:

- Returnable general license devices to manufacturers
- Store for decay, solid P-32, P-33, S-35, Cr-51, Co-57, Fe-59, Zn-65 and I-125
- Store for disposal, such as solid H-3, C-14 and Fe-55
- Store for disposal, irradiated rocks and associated solid waste
- Store for disposal, sealed sources such as H-3 and Ni-63
- Store for disposal, an assortment of miscellaneous sources found on campus. These sources include things such as radium, uranyl acetate, and various standards.

5.1.4.1 Segregation of waste:

Store for decay waste is kept primarily in room 6 while store for disposal waste (C-14 and H-3) are normally kept in room 8

5.1.5 Inventory and Accounting Requirements

All waste is logged into the inventory record at the time it is brought to the waste site.

All waste is logged out of the inventory record at the time of ultimate disposal, whether to radioactive waste landfill or for incineration as biohazard waste following decay.

In general the waste site inventory does not account for half-life, so the actual amount of radioactivity actually present will be substantially over-estimated by our accounting system.

5.1.6 Storage of Waste Products

5.1.6.1 Shielding

All solid waste must be stored in such a manner that the exposure at the waste container (or shield) is less than 0.5 mR/h. If these values cannot be achieved, additional shielding or an accelerated waste pick-up schedule is required.

5.1.6.2 Miscellaneous

- Each waste bag must be of substantial construction, and clearly marked as radioactive.
- Each bag must be labeled with the isotope identity and activity.
- Each bag must be "logged out" from the laboratory's inventory, when picked up.
- "Solid Waste" means no liquid.
- Do not mix isotopes, even of similar half-life. If the experimental procedure calls for mixed isotope work, notify the RSO.
- When required (e.g., P-32, Fe-59, Zn-65 and I-125) SHIELD your laboratory waste container.

5.1.6.3 Store for Decay

Radioactive waste of half-life less than 275 days is stored at the waste site for ten half-lives. At this time, each package is surveyed by the RSO to ensure no activity remains. Decayed waste will be packaged as biohazard waste and shipped accordingly for incineration or shredding.

5.1.6.4 Mixed Waste

Research possibly producing mixed waste should be thoroughly discussed with the radiation safety officer and the hazardous waste manager. Every effort should be made to minimize mixed waste production.

5.1.7 Disposal of Radioactive Solid Waste

Solid waste is divided into two broad categories, based on half-life. Short half-life isotopes (less than 120 days, except for other specific isotopes provided for within the license) are stored for decay for ten half-lives, surveyed, and disposed as normal waste. Long half-life isotopes are stored for eventual transfer to an approved radioactive waste site. All wastes, irrespective of half-life, are stored at the Temporary Waste Storage Facility.

The RSO will pick up both categories of waste from the laboratories upon request. This request must be in writing using the "Request for Radioactive Waste Pick Up" form (see Appendix G).

5.1.7.1 Disposition of Radiation Producing Machines

The RSO must be notified of any intent to dispose, store, recycle abandon, salvage for parts, or give away any radiation producing machine.

5.1.8 Disposal of Mixed Waste

If a laboratory generates a waste containing a radioisotope(s) and an USEPA/Maine DEP defined Hazardous Waste, the laboratory generates mixed waste. In regulatory terms, a Hazardous Waste is a chemical waste that exhibits at least one of four characteristics—ignitability, corrosivity, reactivity, or toxicity – or is specifically listed on one of four hazardous wastes lists developed USEPA and MDEP.

In general terms, Hazardous Waste is any liquid, solid, contained gas or sludge that you intend to dispose of and which has properties that make it dangerous or potentially harmful to human health or the environment if not disposed of properly.

Examples of mixed waste include: tritiated benzopyrene in ethyl acetate (a Flammable Characteristic Waste/Listed Waste), P-32 labeled GTP in chloroform (a Toxicity Characteristic Waste), and C-14 labeled acetic acid, pH<2 (a Corrosive Characteristic Waste).

If you are uncertain whether or not your laboratory might generate mixed waste, please contact RSO and/or Safety Management. Mixed waste must be handled and stored as hazardous and radioactive according to SM's Hazardous Waste – Satellite Accumulation Area Procedure and radioactive material storage. Mixed waste containing less than .05 microcurie (applies to H-3 and C-14 only) per gram of medium used for liquid scintillation counting or gram of animal tissue, averaged over the weight of the entire animal is considered "as if it were not radioactive" and is handled as a non-radioactive hazardous waste.

Disposal of mixed waste at the University of Maine is infrequent and generally involves a specific pickup. Consequently, all campus procedures generating mixed waste shall be reviewed by the RSC. This review will examine substitution options.

5.1.9 Disposal to Sewer System

Radioactive material may be disposed of via the sewer system provided that <u>all</u> of the following criteria are met:

- The material is readily soluble or dispersible in water.
- Each sink used for radioactive disposal must be clearly labeled.
- Only one sink per laboratory may be used for this purpose. The RSO may grant exemptions.
- The material must be flushed with copious amounts of water. Five liters per microcurie is reasonable. Run the water slowly, determine the flow rate (liters per minute), and calculate the amount of time required.
- All sink disposals must be recorded. Records must be kept of the identity and activity of all isotopes disposed to the sewer system.
- The material is not a hazardous waste.

Daily limits on activity disposed to the sewer system must not be exceeded as indicated below:

Monthly and annual limits for disposal via the sewer system are listed in SMRRRP Section D.18, along with appendices D.A and D.B. In addition, the University may not release more than 1 Curie of carbon-14, nor more than 5 Curies of hydrogen-3, in any year. Exclusive of hydrogen and carbon, the University may not discharge more than 1 Curie total of all other isotopes.

Isotope	Daily Sink Limit in µCi	Monthly Facility Limit in mCi
H-3	5000	415
C-14	1500	82
P-32	200	10
P-33	100	5
S-35	200	10
Cr-51	100	5
Fe-59	100	5
I-125	200	10

Providing it can be done safely and conveniently, store liquid waste for several half-lives prior to sink disposal.

5.1.10 Donations to a Second Party

All donations to a second party will be accomplished by the RSO, who will also retain appropriate documentation.

5.2 Recordkeeping

All radiological records shall use the SI units Becquerel (Bq), Gray (Gy), Sievert (Sv) and Coulomb per kilogram (C/kg), or the special units Curie (Ci), Rad, Rem, and Roentgen (R), including multiples and subdivisions and clearly, legibly and durably indicate the units of all quantities in records required by this section.

Each record required by this section shall be legible throughout the specified retention period. The record shall be the original, a reproduced copy, or stored in electronic format. Copies in electronic forms must be authenticated by authorized personnel. Adequate safeguards against tampering, loss and destruction shall be maintained.

6 Training and Education

The radiation instruction program consists of several complementary parts, geared toward different occupational needs and backgrounds. Included are this manual, topical RSO updates, an initial training series provided by the RSO, requirements for annual refreshers, training for ancillary personnel, and RSO meetings with individuals and working groups.

> **Authorized Users:** Initial instruction in radiation safety, which includes content from this manual along with annual refresher training, is required and is provided by the RSO.

Ancillary Personnel: Instruction provided by the RSO at appropriate frequency.

6.1 Initial Employee Training

All individuals working with ionizing radiation must attend an initial training session with the RSO.

6.2 Annual Employee Training

All Authorized Users with active or inactive laboratories and all individuals working with ionizing radiation must complete annual refresher training.

6.3 Training Schedule

Initial employee training is scheduled at the beginning of each semester and then monthly throughout the year. Special arrangements can be made by contacting the RSO. Annual training is accomplished by users reading refresher training material, which can be accessed either on the web or by request of Safety Management.

6.4 Training Contents

Instruction content is outlined below by user category:

6.4.1 Registered Radiation Workers

a. Introduction to radioactivity
b. Interaction of radiant energy with matter
c. Radiation type, units, and calculations
d. Biological effect of radiation
e. Radiation safety principles
f. Engineering controls, personal protective equipment
g. Dosimetry
h. Surveillance, monitoring, and records
i. Regulatory issues and security
j. Individual responsibility
k. RSO responsibility
l. Waste Disposal
m. S.O.P's
n. ALARA
o. Personal Protective Equipment
p. Emergencies

6.4.2 Ancillary Personnel

a. Radiation, general issues
b. Radiation, specific types and locations
c. Warning signs and notification
d. Procedures for working in restricted areas
e. Individual responsibility
f. RSO responsibility

g. Emergencies

6.4.3 Emergency Responders

a. Introduction to radioactivity
b. Radiation type and characteristics
c. Biological effects of radiation
d. Radiation safety principles
e. Type, quantity, and location of all campus sources
f. Fire in a restricted area
g. Dosimetry and decontamination
h. External dose, internal dose
i. Radiation incident preparedness

7 Emergency Response Activities

7.1 Radiation Emergencies

7.1.1 Laboratory Notification to RSO

In the event of a major incident (8.1.2, below) laboratories should contact Public Safety (911). In the event of a minor incident, laboratories should contact the RSO directly.

7.1.2 Procedures

7.1.2.1 Major Incidents: Potential Health or Environmental Hazard

In the event of the spread (or suspected spread) of radioactive contamination over a significant portion of a room or larger area, or if the contamination is greater than 1 millicurie, then:

1. Vacate the area. Leave behind any contaminated (or suspected contaminated) clothing or other articles.

2. If safe to do so, turn off all ventilation systems and close all doors and windows.

3. Keep all people out of the area, except for trained incident response personnel.

4. Call the Department of Public Safety (911). Public Safety will notify the RSO.

5. Do not attempt decontamination except as directed by the Radiation Safety Officer. Be prepared to describe, locate, and produce needed spill clean-up materials.

7.1.2.2 Minor Incident: No immediate Health or Environmental Hazard

1. Determine the extent of contamination. If prepared and equipped, the individual should monitor, decontaminate the area, and monitor again. Non-essential individuals should be kept away.

2. If there is any uncertainty about the scope of the contamination, clean-up and disposal methods, monitoring, or record keeping, notify the RSO.

3. Record the incident in writing, and forward a copy to the RSO. This incident report will include the time, date, and location; the individuals, isotope and activities involved; initial and final survey results, and brief narrative describing the events.

7.1.2.3 Personnel Contamination

In the event that persons are contaminated as a result of a radiation incident, and DO NOT require any other sort of first aid then:

1. Personnel should be decontaminated as quickly as possible using the least drastic means necessary. Decontamination efforts should begin with mild methods (e.g., blotting, copious flushing with water) which should be continued as long as they are effective, and progress to harsher methods only as required. Medical supervision is required when harsh materials or methods are used. Extreme care should be taken to prevent the spread of contamination to any skin or body opening. All liquids generated and materials used during decontamination must be collected and handled as radioactive waste. Personnel performing the decontamination should take all necessary precautions to protect themselves.

2. Immediately notify the RSO and the Department of Public Safety. State "Needs radiation decontamination procedures". In the event that persons are contaminated as a result of radiation incident, and DO require first aid, then:

    a. Efforts to save life take precedence over decontamination issues.

    b. Immediately notify emergency responders and the RSO. State "Needs emergency medical treatment and radiation decontamination".

7.1.2.4 Ingestion of Radioactivity

In the event an individual swallows radioactive material, immediately contact the Department of Public Safety and the RSO.

7.1.3 Notifications

Actual or suspected exposures to radiation, including ingestion or inhalation of radioactive materials or contamination of persons or facilities must be reported immediately to the Radiation Safety Officer.

If the incident is of sufficient magnitude, the Maine Radiation Control Program must be notified immediately. Threshold for both personnel exposures and general contamination are listed in SMRRRP sections D.52 and D.53.

In addition to immediate notification, the RSO will produce a written report. This report will be sent to the Radiation Control Program.

7.2 Physical Hazard Emergencies

7.2.1 Radioactive Material Damage under Natural Disasters

7.2.1.1 Fire

In the event of a fire in a restricted area, pull the fire alarm or call 911. Do not attempt to retrieve radioactive sources from storage or experimental use. Be prepared to describe the identity, activity, and location of all radioactive sources present in the area.

7.2.1.2 Floods

All radioactive material shall be stored in such a manner as to minimize any hazard due to floods.

7.2.1.3 Power Failure

If power is required to safely store or use radioactive material, steps shall be taken to minimize any hazard posed by power failure. For example, work taking place in a fume hood must be readily sealable against dispersal to the work place. Shutdown protocols must be in place if power is necessary to prevent a temperature-induced dispersal to the work place.

7.3 Notification Procedures

In the event of an incident or emergency involving radiation, individuals are to notify the Department of Public Safety. Public Safety will notify the RSO. External emergency responders may be called in by the RSO, the Facility Emergency Coordinator, or the Department of Public Safety.

7.3.1 Regulatory Notification

Depending on the scope of the problem, the RSO will make the required Agency (i.e., NRC, RCP, etc.) notifications.

7.3.2 Campus Notification

Emergency and incident contact instructions shall be posted in each restricted area.

8 Recordkeeping

Accurate and up to date records are the only means available to demonstrate the safe acquisition, use and disposal of radioactive material. This information is the only way to determine things such as: the location and inspection status of X-ray machines and sealed sources, the amount of waste at the University of Maine Waste Site or released to sewer, the identity and training requirements of any worker, or any potential hazards associated with a fire or other campus emergency. Detailed records retention responsibilities are presented in the following subsections.

8.1 Personnel and Equipment Monitoring Records

Radiation Safety Officer shall:

- Maintain records of detection instrument calibration results for three years.
- Maintain records of the results of surveys to determine the dose from external sources of radiation in the assessment of individual dose equivalents for as long as the University of Maine maintains its license.
- Maintain records of the results of measurements and calculations used to determine individual intakes of radioactive material and used in the assessment of internal dose for as long as the University of Maine maintains its license.
- Maintain records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment for as long as the University of Maine retains its license.
- Maintain records of individual's prior occupational dose for as long as the University of Maine retains its license.
- Maintain, where applicable, records of occupational whole body deep dose equivalent, eye dose equivalent, shallow dose equivalent, and the dose equivalent to the extremities for as long as the University of Maine maintains its license.
- Maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public for as long as the University of Maine maintains its license.

8.1.1 Radiation Safety Record Categories

Administrative
Accidents/incidents file
Emergency planning
Policies, procedures, and standards
Program reviews

Authorized Users
Authorized isotopes and possession limits
Authorized users
Individual lab inspections/surveillance

Dosimetry
Dosimeter specifications
Exposure evaluation
Exposure: other facilities during current employment
Exposure: prior employment
External/internal exposure records.
Statistical summaries
Transfer of records
Unusual exposures

Inspections
Inspections/surveillance
Corrective actions

Licenses
Licenses, authorizations, and amendments

Radiation Safety Committee
RSC minutes, letters, and positions

Sealed Sources
Device evaluations
Inventory
Wipe Test Records

Survey Equipment
Calibration and maintenance
Instrument specifications
Inventory

Training
Instructional outlines, handouts and materials
Training records

Unsealed Sources
Inventories
LSC calibration and efficiency data

Waste
Sanitary Sewer Releases
State LLRW reports
Transportation file
Waste management and minimization
Waste site log

X-Ray Equipment
Inventory
RSO and Qualified Expert inspections

Records Management
Hard copy
Computer records
Retention period
Storage precautions

8.2 Medical Monitoring Records

The Medical Monitoring vendor will maintain all required medical monitoring records.

8.3 Training Records

All initial and annual radiation training materials will be maintained for five years by the Radiation Safety Officer at a centralized location.

Records of reviews and updated annual training materials shall replace dated annual training materials as necessary by the Radiation Safety Officer.

Training attendance forms will be maintained for five years by the Radiation Safety Officer.

8.4 Procurement Records

Authorized Users shall maintain accurate and current records indicating the identity, activity, location, and disposition of all radioactive materials in their possession. These records shall be available for inspection by the RSO, and summaries shall be sent to the RSO quarterly for the campus-wide inventory.

8.5 Disposal Records

The RSO shall maintain records of disposal of licensed or registered material (including burial in soil prior to 1981) for as long as the University of Maine maintains its license. The RSO shall also maintain records related to the decommissioning of the facility for as long as the University of Maine retains its license.

8.6 Transportation Records

The RSO will maintain all required transportation records.

8.7 Survey and Audit Records

The RSO shall maintain records of the provisions of the Radiation Safety Program for as long as the University of Maine retains its license.

The RSO shall maintain records of all audits and reviews of Radiation Safety Program content and implementation for three (3) years after the record is made.

Authorized Users shall maintain all survey and wipe test records for a period of three (3) years.

8.8 Program Review and Update

The Radiation Safety Program will be reviewed annually. This review will examine written content, field implementation, administrative control, records and documentation, ALARA issues, training requirements and waste management. Detailed appraisal criteria are listed in Appendix H.

8.9 Archiving of Records

Should the university terminate its license the records listed they shall be turned over to the Department of Human Services Division of Health Engineering.

9 Definitions

Absorbed Dose: The amount of energy imparted to matter by ionizing radiation per unit mass irradiated material (see Rad)

Absorption: The phenomenon by which radiation imparts some or all of its energy to any material through which it passes.

Activity: The number of nuclear disintegrations occurring in a given quantity of material per unit time (see Curie)

Alpha Particle: A strongly ionizing particle emitted from the nucleus during radioactive decay having mass and charge equal in magnitude to a helium nucleus, consisting of 2 protons and 2 neutrons with a double positive charge.

Annihilation: (Electron) An interaction between a positive and negative electron; their energy, including rest energy, being converted into electromagnetic radiation (annihilation radiation).

Atom: Smallest particle of an element which is capable of entering into a chemical reaction.

Autoradiograph: Record of radiation from radioactive material in an object, made by placing the object in close proximity to a photographic emulsion.

Background Radiation: Ionizing radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, etc.

Beta Particle: Charged particle emitted from the nucleus of an atom, having a mass and charge equal in magnitude to that of the electron.

Becquerel: The quantity of any radioactive material in which the number of disintegrations is 1 per second. Abbreviated Bq.

Bremstrahlung: Electromagnetic (x-ray) radiation associated with the deceleration of charged particles passing through matter. Usually associated with energetic beta emitters, e.g. phosphorus-32.

Calibration: Determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors.

Contamination, Radioactive: Deposition of radioactive material in any place where its presence may be harmful. The harm may be in vitiating the validity of an experiment or a procedure, or in actually being a source of excessive exposure to personnel.

Carrier Free: An adjective applied to one or more radioactive isotopes of an element in minute quantity, essentially undiluted with stable isotope carrier.

Count (Radiation Measurements): The external indication of a device designed to numerate ionizing events. It may refer to a single detected event or to the total registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse.

Critical Organ: That organ or tissue, the irradiation of which will result in the greatest hazard to the health of the individual or her descendants.

Curie: The quantity of any radioactive material in which the number of disintegrations is 3.7×10^{10} per second. Abbreviated Ci.

Millicurie: One-thousandth of a Curie (3.7×10^{7} disintegrations per second). Abbreviated mCi.
Microcurie: One-millionth of a Curie (3.7×10^{4} disintegrations per second). Abbreviated uCi.
Picocurie: One-millionth of a microcurie (3.7×10^{-2} disintegrations per second or 2.22 disintegrations per minute). Abbreviated pCi.

Decay, Radioactive: Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

Dose: A general term denoting the quantity of radiation or energy absorbed in a specified mass. For special purposes it must be appropriately qualified, e.g. absorbed dose.

Dose Equivalent: A quantity used in radiation protection expressing all radiation on a common scale for calculating the effective absorbed dose. The unit of dose equivalent is the rem, which is numerically equal to the absorbed dose in rads multiplied by certain modifying factors such as quality factor, distribution factor, etc.

Efficiency (Counters): A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably so it is well to make sure which factors (window, transmission, sensitive volume, energy dependence, etc.), are included in a given case.

Electron: Negatively charged elementary particle which is a constituent of every neutral atom. Its unit of negative charge equals 4.8×10^{-10} electrostatic units or 1.6×10^{-19} coulombs. Its mass is 0.000549 atomic mass units.

Electron Capture: A mode of radioactive decay involving the capture of an orbital electron by its nucleus. Capture from the particular electron shell is designated as "K-electron capture", "L-electron capture", etc.

Electron Volt: A unit of energy equivalent to the amount of energy gained by an electron in passing through a potential difference of 1 volt. Abbreviated eV. Larger multiple units of the electron volt frequently used are: KeV for thousand electron volts, MeV for million electron volts and GeV for billion electron volts.

Film Badge: A packet of photographic film used for the approximate measurement of radiation exposure for personnel monitoring purposes. The badge may contain two or more films of differing sensitivity, and have filters which shield parts of the film from certain types of radiation.

Gamma Ray: Very penetrating electromagnetic radiation of nuclear origin. Except for origin, identical to x-ray.

Geiger-Mueller (G-M) Counter: Highly sensitive gas-filled detector and associated circuitry used for radiation detection and measurement.

Genetic Effect of Radiation: Inheritable changes, chiefly mutations, produced by the absorption of ionizing radiations. On the basis of present knowledge these effects are purely additive, and there is no recovery.

Gray: The SI unit of absorbed dose. One gray (Gy) is equal to an absorbed dose of 1 joule per kilogram (100 rad).

Half-Life, Biological: The time required for the body to eliminate one-half of an administered dose of any substance by the regular process of elimination. This time is approximately the same for both stable and radioactive isotopes of a particular element.

Half-Life, Effective: Time required for a radioactive nuclide in a system to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

$$\text{Effective half-life} = \frac{\text{Biological half-life X Radioactive half-life}}{\text{Biological half-life + Radioactive half-life}}$$

Half-Life, Radioactive: Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

Half Value Layer (Half thickness): The thickness of any specified material necessary to reduce the intensity of an X-ray or gamma ray beam to one-half its original value.

Health Physics: A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

Inverse Square Law: The intensity of radiation at any distance from a point source varies inversely as the square of that distance. For example: If the radiation exposure is 100R/hr at 1 inch from a source, the exposure will be 0.01 R/hr at 100 inches.

Ion: Atomic particle, atom, or chemical radical having an electrical charge, either negative or positive.

Ionization: The process by which a neutral atom or molecule acquires either a positive or negative charge.

Ionization Chamber: An instrument designed to measure the quantity of ionizing radiation in terms of the charge associated with ions produced within a defined volume.

Ionization, Specific: The number of ion pairs per units length of path of ionizing radiation in a medium; e.g. per centimeter of air or per micron of tissue.

Ionizing Radiation: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

Isotopes: one of two or more species of atom having the same atomic number, hence constituting the same element, but differing in mass number.

Labeled Compound: A compound consisting, in part, of labeled molecules. By observations of radioactivity or isotopic composition this compound or its fragments may be followed through physical, chemical or biological processes.

Monitoring, Radiation: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

Area monitoring: Routine monitoring of the level of radiation or of radioactive contamination of any particular area, building, room, or equipment.

Personal Monitoring: Monitoring any part of an individual, his breath, excretions, or any part of his clothing. (see Radiological Survey)

Neutron: Elementary particle with a mass approximately the same as that of a hydrogen atom and electrically neutral. It has a half-life in minutes and decays in a free state into a proton and an electron.

Nuclide: A species of atom characterized by its mass number, atomic number, and energy state of its nucleus, provided that the atom is capable of existing for a measurable time.

Protective Barriers: Barriers of radiation absorbing material, such as lead, concrete, plaster, and plastic, that are used to reduce radiation exposure.

Protective Barriers, Primary: Barriers sufficient to attenuate the useful beam to the required degree.

Protective Barriers, Secondary: Barriers sufficient to attenuate stray or scattered radiation to the required degree.

Rad: means the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 erg per gram or 0.01 joule per kilogram (0.01 Gy).

Radiation:

1. The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic, sound or elastic waves.

2. The energy propagated through a material medium as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term "radiation" or "radiant energy", when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified according to frequency as Hertzian, infrared, visible (light), ultraviolet, X-ray and gamma ray.

3. By extension Corpuscular emission, such as alpha and beta radiation, or rays of mixed or unknown type, or as cosmic radiation.

Radioactivity: The transformation of unstable atomic nuclei by the emission of radiation.

Radiological Survey: Evaluation of the radiation hazards incident to the production, use or existence of radioactive materials or their sources of radiation under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

Radiotoxicity: Term referring to the potential of an isotope to cause damage to living tissue by absorption of energy from the disintegration of the radioactive material introduced into the body.

Relative Biological Effectiveness (RBE): For a particular living organism, the ratio of the absorbed dose of a reference radiation that produces a specified biological effect to the absorbed dose of the radiation of interest that produces the same biological effects.

Rem: The special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, distribution factor, and other necessary modifying factors.

Restricted Area: means any area access to which is controlled by the licensee or registrant for purposes of protection of individuals from exposure to radiation and radioactive material. A restricted area shall not include any areas used for residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

Roentgen (R): The quantity of x-ray or gamma radiation such that the associated corpuscular emission per 0.001293 grams of dry air produces, in air, ions carrying one electrostatic unit of charge of either sign. The roentgen is the special unit of exposure.

Milliroentgen (mR): A sub-multiple of the roentgen equal to one one-thousandth (1/1000th) of a roentgen. (see Roentgen)

Scintillation Counter: A counter in which light flashes produced in a scintillator by ionizing radiation is converted into electrical pulses by a photomultiplier tube.

Shielding Material: Any material which is used to absorb radiation and thus effectively reduce the intensity of radiation, and in some cases, eliminate it. Lead, concrete, aluminum, water, and plastic are examples of commonly used shielding material.

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

Specific Activity: Total radioactivity of a given nuclide per gram of a compound, element or radioactive nuclide.

Tracer, Isotopic: The isotope or unnatural mixture of isotopes of an element which may be incorporated into a sample to make possible observation of the course of that element, alone or in combination, through a chemical, biological, or physical process. The observations may be made by measurement of radioactivity or of isotopic abundance.

Thermoluminescent Dosimeter: A dosimeter made of a certain crystalline material which is capable both of storing a fraction of absorbed ionizing radiation and releasing this energy in the form of visible photons when heated. The amount of light released can be used as a measure of radiation exposure to these crystals.

10 References

State of Maine Rules Relating Radiation (SMRRRP)
10 CFR Parts 19, 20, 30-33 and 71
29 CFR 1910.1096
49 CFR Part 171 to 178
State Licenses – 19801G, 19827-01 and 19827-02SNM

11 Revisions

Date	Type	Page Numbers
Revision 1: November 20, 2009	RSC now meets quarterly; changes to meeting and report schedule.	5.3 Radiation Safety Committee
	Major changes in wording of external exposure monitoring requirements; addition of area monitor requirements for interlocked, closed-beam analytical X-ray equipment.	6.7 and 6.7.1 External Personnel Monitoring
	Changes in wording.	6.7.6 Access to Dose Records
	Major changes to paragraph format and wording	7.4.1 Ordering Materials
	Addition of package label requirements (e.g., package limited quantities statement).	7.4.2 Receipt and opening of containers
	Major change regarding creation of mixed waste and minimization efforts.	9.1.6.4 Mixed Waste
	Major changes in wording and procedural requirements.	9.1.8 Disposal of Mixed Waste
Revision 2: December 31, 2009	Minor (added ISO Forms)	
	Change to section title and criteria for external monitoring.	6.7.1 External Monitoring
	Changed to limit exposure records that will be sent out automatically to > 1% of regulated dose.	6.7.6 Access to Dose Records
Revision 3: December 14, 2010	Categorized appendices to include forms and procedures with ISO headers.	
	Added signatures of Associate Radiation Safety Officers	3 University of Maine Approval
Revision 4: August 14, 2013	Revised requirement for an Authorized User to retain	Section 6.1.1 Temporary Inactive Status of an Authorized User

Date	Type	Page Numbers
	"Authorized User" status during periods when the laboratory is "inactive". Clarified difference between the statuses assigned to Authorized Users and their laboratories. Simplified language pertaining to annual training requirements. Updated signature page.	Laboratory. Section 10.2 Annual Employee Training. 3 University of Maine Approval
Revision 5: May 12, 2015	Updated signature page. Removed title of "Associate Radiation Safety Officer"	3 University of Maine Approval
Revision 6: September 11, 2017	Updated signature page. Changed title of Vice President for Administration and Finance since position no longer exists. Incorporated UMaine Vice President for Research into programming. Minor clean up.	2-4 University of Maine Approval and Responsibilities 7 Purchasing title change
Revision 7: September 2018	Layout, headings. and formatting changes. Updated Signature page. Changed the department name from Safety and Environmental Management to Safety Management (SM). Added paragraph "The University of Maine Radiation Safety Program Organization"	Throughout document
Revision 8: June 2019	Clarified new administrative relationship to Safety Management for support Clarified quarterly meeting of RSC to allow for times when meetings are not necessary Cleaned up language and formatting Added process document as Appendix with new SM Director added	Page 2 Page 3 Throughout Added at end
Revision 8.1 July 2019	Additional information on administrative relationships as result of UMS reorganization of services Minor cleanup of grammar Added mobile phones as source of potential contamination equivalent to eating and drinking in labs	Page 2, 3, throughout, and end

Date	Type	Page Numbers
	Expanded beyond water fountains areas near benchtop radionuclide work as considerations for contamination testing	

Appendix A – Application and Registration Forms

- Authorized Isotope User Application
- Authorized Isotope User Approval
- Sealed Source Registration
- Ionizing Radiation Producing Equipment Registration
- Survey Meter Registration

Forms are available on the Safety Management (SM) (SM-Documents) web page or by contacting SM at 207-581-4055 | email sem@maine.edu

Appendix B – Training Forms

- Radiation Safety Initial Training Roster

Forms are available on the Safety Management (SM) (SM-Documents) web page or by contacting SM at 207-581-4055 | email sem@maine.edu

Appendix C – Exposure Monitoring and Dosimeter Forms

- Personal Dosimeter Application
- Personal Dosimeter Radiation Exposure Report
- Request for Previous Occupational Exposure
- Annual Dosimetry Report

Forms are available on the Safety Management (SM) (SM-Documents) web page or by contacting SM at 207-581-4055 | email sem@maine.edu

Appendix D – Safety Procedures

- Wipe Testing Procedure

Forms are available on the Safety Management (SM) (SM-Documents) web page or by contacting SM at 207-581-4055 | email sem@maine.edu

Appendix E – Inventory Forms

- Radioisotope Quarterly Inventory Checksheet
- Radioisotope Quarterly Unsealed Inventory Report
- Isotope Receipt Form
- Radionuclide Receipt, Utilization, and Disposal Record

Forms are available on the Safety Management (SM) (SM-Documents) web page or by contacting SM at 207-581-4055 | email sem@maine.edu

Appendix F – Audit and Inspection Forms

- Radiation Safety Program Annual Review
- X-ray Producing Equipment Inspection Form
- Radioisotope Lab Audit
- Active Lab Monthly Inspection Briefs

Forms are available on the Safety Management (SM) (SM-Documents) web page or by contacting SM at 207-581-4055 | email sem@maine.edu

Appendix G – Waste Management Forms

- Request for Radioactive Waste Pick-up
- Mixed Waste Sign

Forms are available on the Safety Management (SM) (SM-Documents) web page or by contacting SM at 207-581-4055 | email sem@maine.edu

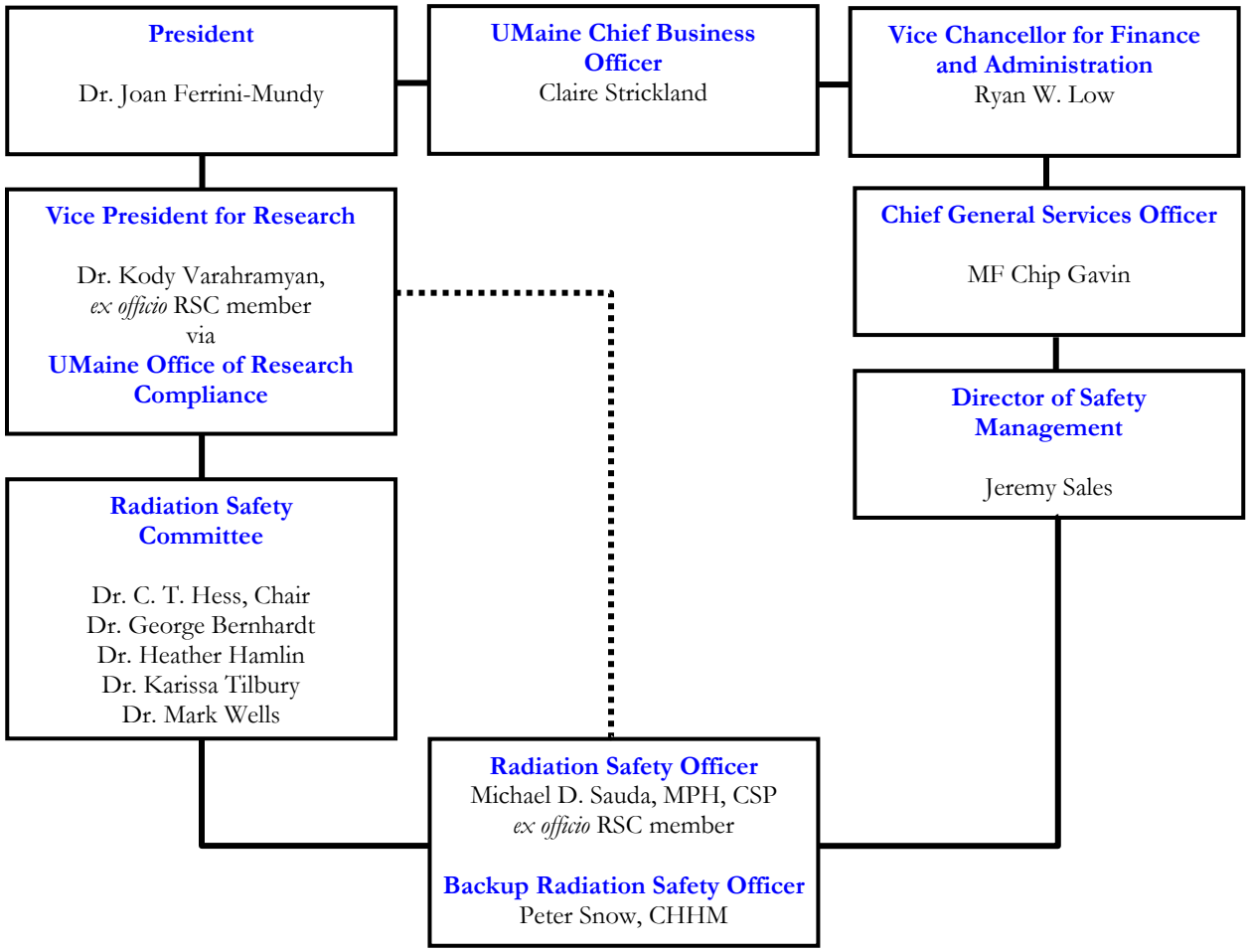
Appendix H – Radiation Safety Program Organization – UMaine

The University of Maine (UMaine) Radiation Safety Program is based on shared governance and cooperation between the UMaine Radiation Safety Officer (RSO) and the UMaine Radiation Safety Committee (RSC) and the administration of UMaine including the UMaine President, UMaine Chief Business Officer, and the Vice President for Research, and Safety Management.

The UMaine RSO has delegated authority from the UMaine President for the oversight of radiation safety for UMaine, its associated locations, including the Darling Marine Center, the Technical Research Center (TRC) in Old Town, and associated remote sites. The UMaine RSO is a non-voting *ex officio* member of the UMaine Radiation Safety Committee (RSC). The UMaine RSC has members representing all uses of ionizing and non-ionizing radiation at UMaine and reports directly to the Vice President for Research. The UMaine Vice President for Research is a non-voting *ex officio* member of the UMaine RSC and provides administrative authority through the President of University of Maine.

The UMaine RSO provides reports, statuses, information other programmatic information to the UMaine RSC formally on a quarterly basis. Additionally, the UMaine RSC can be convened by any RSC member to address issues that may be of concern. The UMaine RSC acting as it sees fit regarding radiation program issues may elevate concerns to Vice President for Research and/or Director of Safety Management.

The UMaine RSO, through their appointment by University of Maine and Safety Management, can request financial or administrative actions through the Director of Safety Management as needed to support the UMaine Radiation Safety Program. Examples of financial actions supported include budgeting and allocation of funds for dosimetry programs, instrument calibration, licensing and fees, investigations, and waste handling. The Director of Safety Management makes these requests through the Chief General Services Officer and in consultation with the Chief Business Officer for the University of Maine.



Appendix I – Annual Review Appraisal Criteria

The Radiation Safety Program will be reviewed annually. This review will examine written content, field implementation, administrative control, records and documentation, ALARA issues, training requirements and waste management.