Guidelines for the Use of Radioactive Materials in Research

Office of Radiation Safety
Medical College of Wisconsin

Contents

Abbreviations Used in this Guide

FH	Froedtert Memorial Lutheran Hospital
MCW	Medical College of Wisconsin
NRC	U.S. Nuclear Regulatory Commission
State	State of Wisconsin, Department of Health and Family Services, Radiation Protection Section
ORS	Office of Radiation Safety
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
RAM	Radioactive Material
NCRP	National Council on Radiation Protection and Measurements
ICRP	International Council on Radiation Protection
mrem	millirem
Ci	curie
mCi	millicurie
μCi	microcurie
ALI	Annual Limit on Intake

I. Organization and Responsibilities

A. Management Policy Statement

The Medical College of Wisconsin (MCW) is licensed by the State of Wisconsin for radioactive materials (RAM) for clinical and research applications at facilities located at MCW and Froedtert Hospital (FH). The license is of broad scope for the use of sealed and unsealed radioactive sources. The Administration of MCW is responsible for the maintenance of the license and the activities governed by the State. FH and MCW are jointly responsible for the implementation and review of the Radiation Safety Program to ensure that it conforms to specific license conditions and any other applicable local, state or federal regulations.

The Radiation Safety Program is directed and monitored by the Radiation Safety Committee (RSC). The RSC is an administrative committee responsible for the oversight of RAM under the license. The day-to-day operation of the Radiation Safety Program is provided by the Office of Radiation Safety (ORS) under the direction of the Radiation Safety Officer (RSO). The RSO has been delegated the authority by MCW and FH Administration to address and resolve problems that occur with noncompliance of regulations or State license conditions.

B. Radiation Safety Committee

The RSC is comprised of (but not limited to): the RSO, representatives from the administrations of FH and MCW, an Authorized User from each type of use permitted under the license, a representative of the nursing service and ad hoc members deemed appropriate by the administration.

The responsibilities of the committee regarding the non-human research use of radioactive material are to establish policies and procedures for the use of radioactive material at facilities under the license approve or deny applications for the use of radioactive material and review the Radiation Safety Program with the assistance of the RSO.

C. Office of Radiation Safety (ORS)

The day-to-day operation of the Radiation Safety Program is conducted by ORS. The RSO oversees the ORS and staff. The duties of the staff include monitoring RAM use, identifying radiation safety problems, verifying implementation of corrective actions and ensuring compliance with regulations.

Additionally, the ORS initiates, recommends, and/or provides corrective actions for areas of concern, and instances of non-compliance with State regulations or license conditions. The ORS, under the supervision of the RSO, is delegated the authority necessary to assure the radiation safety requirements are met.

D. Authorized User

An Authorized User is an individual who has been approved by the RSC for use of RAM or ionizing radiation from RAM. Requirements to become an Authorized User are described in Section II, Authorization for the Use of Radioactive Material. Authorized Users are responsible for:

1. Maintaining compliance with applicable Federal, State and institutional rules and regulations governing the use of RAM under their authorization.
2. Maintaining a current inventory of RAM under their authorization.
3. Training personnel who work in or frequent areas where RAM are used under their authorization.
4. Informing the ORS of laboratory staff changes including new hires, terminations and transfers.
5. Submitting to the ORS amendments to change their authorization for RAM use, quantities, rooms, work areas, etc.
6. Returning required correspondence to the ORS in a timely manner.

Failure to comply with responsibilities may result in disciplinary action.

E. Radiation Worker

Individuals who come into contact with RAM or ionizing radiation have certain rights and responsibilities according to state and federal law. These are outlined in State Form PPH 45027 - Notice to Employees, and the MCW Supplement Notice to Employees. These documents are posted in locations where RAM is used or stored.

II. Authorization for the Use of Radioactive Material

The use of RAM or ionizing radiation from RAM is only permitted with the approval of the RSC.

A. Application Process

Applicants to become Authorized Users must complete the following forms, available from ORS or the ORS website:

- *Radioactive Materials Use Application (Non-Human Research)*
- *Statement of Training and Experience*

Instructions for completing these forms are also available from ORS.

Completed forms must be returned to ORS. Upon receipt of the forms, ORS will perform a preliminary review of the application for completeness. The application is then sent to the RSC for review. The RSC meets the second Wednesday of the second month of each calendar quarter (February, May, August and November). Applicants who wish to be considered for approval must provide completed application forms to ORS at least two weeks prior to the RSC meeting date. Requests for an expedited review can be made by contacting the ORS. Applications, whether reviewed by the RSC at a regular meeting date, or by expedited review, must receive signatures from a quorum of the RSC before becoming effective.

B. Authorization Requirements

The applicant shall be a faculty member of MCW and meet the minimum training and experience requirements to qualify as an Authorized User. The RSC may under special conditions grant authorization to a non-faculty member of MCW. Training and experience requirements depend on the type of laboratory being established. Laboratory types are classified one through four. The Laboratory Classification Scheme is presented in Section V (G), Laboratory Classification. Minimum training and experience requirements for each lab type are:

1. Laboratory Type 1 & 2 Training and Experience Requirements

    a. A college degree at the bachelor level, or equivalent training and experience, in such areas as physical, chemical, biological, biomedical, veterinarian or engineering sciences.

    b. At least 40 hours of training and experience in the safe handling of RAM, the characteristics of ionizing radiation, units of radiation dose and quantities, radiation detection instrumentation and the biological effects of radiation exposure appropriate to the types and forms of radioactive material used.

2. Laboratory Type 3 Training and Experience Requirements

   c. Same as for Types 1 & 2 except a total of 80 hours of training and/or experience for quantities of radionuclides, or similar radionuclides, proposed for use or an additional 10 hours of advanced formal training including type three quantities.

3. Laboratory Type 4 Training and Experience Requirements

   d. Same as for Type 3 except a total of 120 hours of training and/or experience for quantities of radionuclides, or similar radionuclides, proposed for use.

Applicants who can provide documentation showing that they were an Authorized User on another Agreement State/NRC license for substantially similar uses and quantities may provide such documentation in lieu of the Statement of Training and Experience form.

C. Authorization Amendments

Any changes in RAM use, possession or order limits, rooms where RAM is used or stored, and the addition of radionuclides to an existing authorization, shall only be permitted with approval of the RSC. Request to Amend Radioactive Material Authorization forms are available from the ORS. The ORS staff will provide assistance in completing the application upon request. The review process is the same as for new applications. The RSO may give interim approval to an amendment request for minor changes, such as:

- Increase of possession limit for previously approved isotope.
- Change of isotope or chemical form for previously authorized use.
- Change of location of use or storage (excluding the BSL-3 facility, see Section F, below).

D. Authorization Termination

When an authorization is terminated the laboratory shall be surveyed for contamination and decontaminated where necessary. Remaining RAM shall be removed by transfer to another Authorized User on this license, transfer to another license, or release as radioactive waste. No RAM is to leave MCW or FH without prior approval by the ORS. Procedures for the transfer of RAM are outlined in Section XIII, Ordering and Transferring RAM.

E. Inactive Status

An Authorized User may go on inactive status when they do not have any RAM in their possession. Inactive status is for Authorized Users who have no plans to use radioactive materials for periods longer than one year, and relieves certain requirements (e.g., inventory, laboratory audits, surveys, and annual refresher training). To establish

inactive status, an amendment request must be sent to the RSC. Active status will be reinstated by filing an amendment to the RSC. The RSC will grant active status upon completion of annual refresher training for the current year. Authorizations inactive for a period of greater than three years may require full reauthorization.

F. BSL-3 Lab Users

Investigators proposing the use of RAM in the BSL-3 facility must apply for approval with a separate Application from other RAM use requests. Under normal circumstances, an investigator who is approved as an Authorized User would only need an Amendment to add a new location of use, as described in Section C. Use of the BSL-3 facility will not be considered a 'minor' addition to an Authorization; a complete Application with formal RSC approval will be required.

III. Training of Radiation Workers

A. Definition of a Radiation Worker

For the purposes of the Radiation Safety Program at MCW, a *radiation worker* is an individual who is likely to receive an *occupational dose* in excess of 1 mSv (100 mrem) in a calendar year.

Occupational dose, as defined by the State in DHS 157.03, "means the dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation, or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee, registrant or other person. Occupational dose does not include dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under s. DHS 157.62 (8), from voluntary participation in medical research programs or as a member of the public."

B. Instruction

Radiation workers shall be given all of the following information annually:

1. The proper storage, transfer and use of sources of radiation in the workplace.
2. Health risks to the individual and potential offspring associated with exposure to radiation and radioactive material, precautions and procedures the individual should use in the workplace to protect themselves and minimize exposure to radiation and radioactive material, and the purposes and functions of protective devices.
3. A worker's responsibility to report promptly to the ORS or MCW management any condition which may constitute, lead to or cause a violation of the regulations or a condition of the license.
4. How to respond in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material.

5. Radiation exposure reports provided to workers.

The extent of the instructions provided shall be commensurate with potential radiological health protection problems present in the workplace and shall take into consideration assigned activities during normal and abnormal situations involving exposure to radiation or radioactive material that can be reasonably be expected to occur.

The form *Training and Instruction Checklist* must be completed for each radiation worker as soon as practical after starting to work with RAM in the lab. Upon completion, the form must be signed by both the radiation worker and the Authorized User and the completed form sent to the ORS.

Training of radiation workers may be accomplished in several different ways:

Direct Training by the Authorized User – In all cases some direct training by the Authorized User or designee is mandatory. The specifics of how and where RAM and RAM records are stored, what precautions should be taken in specific laboratory procedures, authorized use and possession limits, are unique to each lab.

Classroom Training – ORS periodically offers a classroom-based course in radiation safety for laboratory workers. This course is designed to cover training requirements not unique to individual laboratories. All radiation workers should attend this course for initial training.

Computer or Video-based Training – Training materials approved by ORS may be used as a substitute for the classroom training listed above. Contact ORS for approved content.

IV. Exposure Monitoring

A. Radiation Exposure Limits

The goal of the Radiation Safety Program is to keep radiation workers and members of the public exposure to radiation As Low as Reasonably Achievable (ALARA). The occupational exposure reports are reviewed monthly and/or quarterly by ORS. A summary of the occupational exposures is reported to the RSC at the regularly scheduled meetings. The following table lists exposure limits as contained in DHS 157.

Exposure Type	Annual Limits for Radiation Workers		ALARA Level I (per calendar quarter)		ALARA Level II (per calendar quarter)	
	mSv	mrem	mSv	mrem	mSv	mrem
Whole Body	50	5,000	1.25	125	3.75	375
Extremity or Skin*	500	50,000	12.5	1,250	37.5	3,750
Individual Internal Organs	500	50,000	12.5	1,250	37.5	3,750
Lens of the Eye	150	15,000	3.75	375	11.25	1125
Embryo/ Fetus	5	500	0.5/month	50/month	1/month	100/month

* Extremity is defined as: hand, elbow, arm below the elbow, foot, knee, or leg below the knee. Skin dose, measured at 0.007 cm, averaged over 1 cm^2.

B. Radiation Exposure During Pregnancy

Pregnant women occupationally exposed to radiation have the option of limiting radiation exposure to their embryo/fetus to 5 mSv (500 mrem) during pregnancy. To do so, the woman must voluntarily notify ORS in writing of her pregnancy and the estimated date of conception (month and year only).

A declared pregnant woman is defined as a woman who has voluntarily informed the ORS, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

Declaration of Pregnancy – ORS will make available a form letter for the purposes of declaring pregnancy. The employee may choose to use the form letter, or provide her own written notification. The declaration must contain, at a minimum, the name of the

employee, a statement that she is pregnant, her estimated date of conception (month and year only) and the department/service of employment.

The Declaration may be sent to the employee's immediate supervisor, or to ORS. If the immediate supervisor is notified, the supervisor must promptly notify ORS.

ORS will provide information to the Declared Pregnant Woman concerning the health effects/risks associated with exposure of the fetus during pregnancy, and methods of maintaining radiation exposure within the dose limits, and As Low As Reasonably Achievable. ORS will evaluate the working conditions to determine compliance with fetus/embryo radiation exposure limits.

C. Dosimeters

Types

Dosimeters are devices worn by radiation workers to measure actual occupational dose. Three types of dosimeters are commonly available through commercial vendors that meet State accreditation requirements:

- Film badges
- Thermoluminescent Dosimeters (TLD's)
- Optically-Stimulated Luminescent (OSL) Dosimeters

The use of other dosimeter devices for measurement of occupational dose must be approved on a case-by-case basis by ORS.

Requirements

ORS assigns dosimeters, at a minimum, according to the following criteria:

1. Adults likely to receive, in one year from sources external to the body, a dose in excess of 10% of the radiation dose limits.
2. Minors who are at risk of receiving over 10% of the radiation dose limits.
3. Declared pregnant women likely to receive, in one year from sources external to the body, a dose in excess of 1 mSv (100 mrem).
4. An individual entering a high or very high radiation area.
5. An individual working within 6 feet of operating medical fluoroscopic equipment.

Monitoring devices shall be individually assigned and not shared.

Recommendation

ORS recommends that dosimeters be worn by radiation workers who handle beta-emitting isotopes, where the maximum beta energy is greater than 1 MeV, and more than 1 mCi is used per process.

Obtaining a Dosimeter

To request a dosimeter, complete and forward a Personnel Dosimetry Application to ORS. Forms are available at ORS or the ORS website.

General Instruction

To properly use a dosimeter, follow these rules:

Body Dosimeters – film or TLD badges are to be worn at collar level near the neck. If a lead apron is worn, the film badge is to be worn at collar level near the neck outside of the apron.

Extremity Dosimeters – finger TLD rings are to be worn on the finger of the hand where the greatest exposure is anticipated. It is important to wear the ring inside lab gloves, to prevent contamination. When monitoring for beta-emitters, be sure the TLD chip is on the palm side of the hand.

- Wear the dosimeter while in the proximity of ionizing radiation.
- When leaving the work area for the day, leave the dosimeter(s) in a low background area.
- Do not tamper with the dosimeter and protect it from damage.
- Exchange the dosimeter as directed by ORS.
- Notify ORS as soon as practical of any lost or damaged dosimeter.
- Notify ORS as soon as practical of any suspected overexposure or contamination of the dosimeter.
- Do not wear a dosimeter assigned to another individual nor let another individual wear your dosimeter.

Upon termination of employment or if the dosimeter is no longer required, return the dosimeter to the ORS. If you would like a copy of your radiation exposure history while working at MCW, submit a signed request that includes your name, social security number, employee ID number, department, dates of employment, and the address to where you want the report released.

D. Internal Monitoring

In some cases, monitoring for the ingestion or inhalation of RAM may be required. Measurements of internal radionuclides, sometimes called *bioassays*, are generally taken *in vivo*, by direct measurement, or *in vitro*, by measurement of biological samples.

The requirement for bioassays is as follows:

1. Adults likely to receive, in one year, an intake in excess of 10% of the applicable Annual Limit on Intake (ALI) in DFS 157 (excerpt in Appendix B).
2. Minors likely to receive, in one year, a committed effective dose equivalent in excess of 10% of the ALI.
3. Declared pregnant women likely to receive, during the entire pregnancy, a committed dose equivalent in excess of 1 mSv (100 mrem).

To determine when bioassays are necessary, based on the quantity of RAM and the process involved, the methodology described in ANSI HPS N13.39-2001 is referenced. Additionally, a procedure for bioassay analysis is available from ORS.

V. Radioactive Work Areas

Restricted Areas – Locations where RAM is used are defined as *restricted areas*; areas, access to which is limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials (DHS 157.03). Eating, drinking, the application of cosmetics, and smoking are prohibited in restricted areas. Any items relating to the above are also prohibited from these areas (e.g., cups, lunch bags, cigarettes).

Controlled Areas – A controlled area means an area, outside of a restricted area but inside the site boundary, access to which can be limited for reasons of security or other hazards. Controlled areas include any areas within the card-key accessible research and laboratory areas within MCW.

A. Posting and Marking

Each area or room in which there is used or stored licensed material exceeding 10 times the quantity specified in Appendix A to DHS 157 must have a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL."

Each area in which radiation levels could result in an individual receiving a dose equivalent in excess of 50 μSv (5 mrem) in 1 hour at 30 centimeters from the radiation source or from the surface that the radiation penetrates must have a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."

Each area in which radiation levels could result in an individual receiving a dose equivalent in excess of 1 mSv (100 mrem) in 1 hour at 30 centimeters from the radiation source or from the surface that the radiation penetrates must have a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, HIGH RADIATION AREA."

Magenta and yellow tape (as shown below), supplied by ORS, shall be placed on the floor around the radioactive work area (restricted area) except where it has physical boundaries (e.g., walls, heavy equipment, lab benches).

All areas inside the radioactive work area where unsealed sources are used will be labeled with "Caution, Radioactive Material" tape or a similar label. This tape should be minimally placed on the edges of the bench or table, where it can be readily seen. Equipment or glassware that is contaminated from RAM usage should be similarly labeled.

Radioactive work areas that contain self-shielded irradiators, or other sealed sources, are not required to be posted if the external radiation at 30 cm from the housing is less than 5 mR/hr.

B. Radioactive Cold Zones

A radioactive cold zone is an area inside a controlled area where food and drink may be consumed and where RAM is not allowed. This area must include a "cold" pathway to the entrance of the restricted area. Any cleaning or washing of hands or dining utensils, including, but not limited to, silverware, plates and cups shall be in a sink within a "Cold Zone". Trash generated by such washing and cleaning shall be disposed in trash containers in "Cold Zones".

C. Temporary Use Areas

An area can be used as a temporary radioactive work area if the following criteria are met.

1. ORS should be informed that the area will be used as a temporary use area.
2. The area will be used as a "one time only location" or will be used only occasionally as a RAM use area.
3. The RAM in the area is constantly attended or secured.
4. The area, bench tops, and any equipment are marked with the proper "Caution, Radioactive Materials" tape and signs for the duration of the procedure.
5. A contamination survey of the area is conducted after the procedure is completed and the records are maintained by the Authorized User.
6. All caution signs and tape are removed after the area has been monitored and decontaminated, if necessary.

D. Radioactive Storage Areas

Storage areas may consist of a refrigerator, freezer, cold room, cabinet, etc., labeled with a "Caution, Radioactive Materials" or "Caution, Radiation Area" sign as appropriate. Storage areas do not have to be inside a radioactive work area as long as RAM are stored and transported in closed containers. Storage areas outside of controlled areas *must be secured* when not attended.

E. Shared Facilities

If a radioactive work area is shared by more than one investigator, a letter of consent must be signed by each Authorized User and investigator that will use the area. This letter must be forwarded to the ORS and must state that each Authorized User or investigator understands that RAM will be used in the area and that they have a basic understanding of radiation safety principles and use requirements that apply to the particular RAM used.

F. Changing Radioactive Work Areas

If an Authorized User changes radioactive work areas or has an existing work area remodeled, they must inform ORS before the changes are made. Areas that are to be made "cold" or remodeled must have a contamination survey performed prior to any further use or work in the area. If the Authorized User is physically moving their laboratory from one room to another, an amendment to their authorization must be submitted for approval by the RSC. After the laboratory has been relocated, the ORS will perform a closeout survey and remove any markings from the old area.

G. Laboratory Classification

A laboratory classification scheme has been developed based on the relative radiotoxicity and authorized possession limits of specific radionuclides (See Appendix A). The laboratory classification table below details the classification scheme. Only those radionuclides and quantities authorized by the classification and the Authorized Users RAM authorization may be used in that lab. When preparing a new application or amendment, the Authorized User must evaluate the laboratory according to the classification criteria and list it on the application. During the application review process, the final classification determination will be made by the ORS. Classification labels are normally placed near the room number once the lab has been classified.

Note: An Authorized User's training and experience also dictates possession limits. See Section II (B), Authorization Requirements.

H. Radioisotope Laboratory Design Criteria

In general, radioisotope laboratories should be similarly equipped to labs that handle chemical or biological hazards. The nature of the engineering controls available should be commensurate to the hazard of the procedure being planned. A good source for planning a radioisotope lab is ANSI N5.2-1963, "Design Guide for a Radioisotope Laboratory (Type B)," available through ORS.

Ultimately, the Radiation Safety Committee will examine each application and determine appropriate laboratory requirements. These requirements will be listed as use conditions for each authorization.

VI. General Radioactive Material Use

A. Operating Considerations

1. Before any procedure is performed, consideration should be given to the amount and type of RAM being used to determine the need for additional precautions, such as remote handling, hoods, air sampling devices or special working surfaces. Consideration should also be taken for the volume and type of waste generated. ORS will be available for assistance on initial or unusual operations.
2. Determine if an individual will be required to have a personal monitoring device or participate in a bioassay or in vivo counting program. This depends on the radionuclide, quantity, frequency of use, chemical form, and type of work being performed. Refer to Section IV, Exposure Monitoring.
3. Transferring of RAM from one Authorized User to another user under our State license (MCW and FH) may be made only with PRIOR approval from ORS.
4. Gamma emitting radionuclides are to be used and stored in such a way so that the total dose equivalent to individual members of the public does not exceed 1 mSv (100 mrem) in a year or in excess of 0.02 mSv (2 mrem) in any one hour in unrestricted areas.

B. Safety Rules for Working with RAM

1. Wear appropriate protective clothing (e.g., lab coat, gloves, closed-toe shoes).
2. Use remote handling tools, as appropriate.
3. Wash hands and monitor clothing, as appropriate, for contamination after each procedure and before leaving the area.
4. Do not eat, drink, smoke, or apply cosmetics in a restricted room or area where RAM is used.
5. Do not store food, drink, or personal effects with RAM.
6. Store radioactive waste only in specially designated and appropriately shielded receptacles in a secured area.
7. Never pipette RAM by mouth.
8. Transport RAM in appropriately closed and shielded containers.

C. Storage and Labeling of RAM

It is the responsibility of the Authorized User and radiation workers to ensure that RAM is stored and labeled to comply with the following procedures and to promptly report non-compliance to the ORS.

1. The room or area where RAM is stored shall be posted with a "Caution Radioactive Materials" sign. Refer to Section V, Radioactive Work Areas.
2. RAM must be secured from unauthorized access and removal when not in use.
3. Unbreakable containers are recommended for storage of RAM. Radioactive liquids shall not be stored in open containers.
4. Freezers used for storage of RAM shall be kept reasonably free of frost. When defrosting a freezer, caution shall be used to prevent the spread of possible contamination.
5. Radioactive gases and volatile radionuclides shall be stored in a negative pressure airflow hood.
6. Equipment or containers known or suspected to be contaminated with RAM should be marked with an appropriate sign or tape until such contamination is removed.
7. Sinks shall be designated for the disposal of radioactive liquid waste and marked appropriately.
8. Radiation caution signs and tape shall only be used in accordance with the appropriate government regulations. Indiscriminate use of caution tape (e.g., to display notices) is prohibited.

D. Security

Preventing loss or theft of RAM is essential to protect individuals and the environment from unnecessary radiation exposure. The State regulations require that MCW "shall secure licensed or registered radioactive material in an unrestricted area from unauthorized removal or access."

For labs within the card-key access controlled areas within MCW:

- Doors to labs where RAM is used or stored should be closed and locked when unattended.
- Stock vial storage areas containing quantities greater than 10 times the ALI should be in locked cabinets or freezers, with key distribution to essential personnel.

For labs outside the card-key access areas, such as the Eye Institute or FH:

- Doors to labs shall be locked when unattended by department personnel.
- Stock vial storage areas containing quantities greater than 10 times Appendix A of DHS 157 shall be kept locked when unattended.

E. Check and Calibration Sealed Sources

A check source is any RAM less than a generally licensed quantity that is encased in a capsule designed to prevent leakage. Authorized Users may possess and use sealed sources for calibration and reference use.

F. Irradiators

Use of irradiators is limited to individuals whose training and credentials have been reviewed and approved by the RSO. Operators are required to pass a written exam for each type of use and for each irradiator they wish to operate. Contact ORS for specific details and forms.

G. High Energy Beta-Emitter Use

Individual users of high-energy beta-emitters (β_{max} > 1 MeV) in quantities greater than 1 mCi shall:

1. Use low atomic number materials, such as plastic or wood for shielding.
2. Use remote handling devices when appropriate.
3. Wear a TLD ring badge to monitor extremity exposure. Wear the ring so that the TLD chips are on the palm side of the hand.
4. Perform a GM and/or a wipe test survey after each use, but at least at the end of each day of use. The survey is to include, but not limited to, lab bench tops, floors around work area, drawer handles, utensils/equipment, lab coats and bottoms of shoes.

H. Radioiodination

Due to radioactive iodine's radiotoxicity, special safety precautions must be taken. Since free iodine has the ability to volatilize then be inhaled and concentrate in the thyroid, radioiodination procedures shall only be performed in facilities approved by the ORS and by individuals approved by the RSC.

Thyroid scans are required for workers iodinating or observing the iodination if greater than one millicurie is used.

Normally protein is only stable for a few weeks after the iodine is bound. This time duration varies depending on the nature of the protein. After a period of time, the protein is broken down by the radiation, liberating free iodine. Therefore, workers should be cautious when handling old iodinated proteins.

I. Radioactive Material in Animals

Procedures involving the use of RAM in animals may only be done with the knowledge and approval of the Institutional Animal Care and Use Committee (IACUC) and the RSC. Applications for the use of RAM in animals shall be submitted to ORS. Approval by the IACUC and the RSC shall be obtained before any work may begin.

In addition to the Biological Resource Center (BRC) rules and procedures, the following rules and procedures apply to experiments involving RAM in animals in areas under the jurisdiction of MCW or FH.

1. No radioactive animals, tissues or animal wastes may be disposed as normal trash.
2. Cages containing radioactive animals shall be labeled by the investigator bearing the “Caution Radioactive Materials” symbol and stating the identity of the radionuclide(s), the activity, time and date originally given to the animal(s).
3. Personnel having physical contact with such animals, the animal's waste, or the equipment they may have been in contact with shall wear disposable gloves. These gloves are to be disposed in the designated radioactive waste container.
4. Personnel exposed to radioactive animals, wastes, areas, or equipment may require exposure monitoring. Refer to Section IV, “Exposure Monitoring”.
5. Wastes swept up from the floor of any room housing radioactive animals shall be monitored for radiation. If found to be contaminated, the waste shall be disposed in the designated containers in the room.
6. BRC shall inform the ORS of any activity involving RAM which appear to deviate from the approved project's guidelines.
7. Rooms housing radioactive animals shall have the room or area labeled with a "Caution Radioactive Materials" or "Caution Radiation Area" sign, as appropriate. Refer to Section V, “Radioactive Work Areas”.

J. Contamination Surveys

Surveys for contamination must be performed routinely in and around areas where RAM is used and stored. The type and frequency of surveys is dependent on the specific isotope and the quantity in use.

Daily Use of Survey Meters

When a procedure using RAM is performed, a portable survey meter should be available and in use for detecting the presence of contamination during and immediately after completion (for all procedures except those involving H-3). Selection of the proper survey instrument is important; see the table below for a guide to survey instrument selection:

Isotope	Portable Survey Meter
H-3	None*
C-14, S-35, P-32, P-33 (beta or beta-gamma emitters)	Thin-window or pancake Geiger-Muller meter
Cr-51, I-125 (gamma or x-ray emitters)	NaI scintillation detector

* For procedures using > 10 mCi of H-3 per process, monitoring should be performed immediately using liquid scintillation counting.

The proper use of portable survey meters during and immediately following a RAM procedure can reduce the spread of contamination. The use of portable survey meters as described above is for the detection of contamination only, and such surveys are not intended to demonstrate compliance with laboratory contamination limits.

Periodic Laboratory Surveys

Routine, documented surveys for contamination shall be performed to verify that the use of RAM has been contained and will not present an exposure hazard to staff or members of the public. The frequency of such surveys is listed in the table below:

Quantity of RAM in Use at One Time*	Survey Frequency
> 100 × ALI**	Daily
10 - 100 × ALI**	Weekly
< 10 × ALI**	Monthly

* Quantity of RAM involved in the procedure, not the quantity of RAM in the stock vial from which it is withdrawn.
** ALI – Annual Limit on Intake, see Appendix B.

Surveys for contamination should be performed as soon as practical after procedures utilizing RAM have been completed.

In some cases, laboratories may use RAM on an infrequent basis, with stock vials remaining in storage when not in use. If the period during which no RAM procedures are performed exceeds the required survey frequency, documented surveys need not be performed. ***However, a note should be entered into the contamination survey log indicating that no usage of RAM has occurred, and the lab should be prepared to demonstrate that no RAM has been utilized by inventory and purchasing records.***

Survey Locations – A map or floor plan that describes survey locations should be included with records of contamination surveys. All lab benches, equipment, stock vial storage areas, waste disposal areas and sinks utilized with RAM shall be surveyed for contamination. A representative sample of the floors inside restricted areas should also be surveyed. Locations outside the RAM use area should also be surveyed, to confirm that personnel working with RAM do not bring contamination out of the restricted area into an unrestricted area.

Instruments for Contamination Surveys

Liquid Scintillation Counting – The use of liquid scintillation counting (LSC) equipment is the preferred method for analysis of wipe tests for removable surface contamination from beta-emitting isotopes. A few simple instructions are as follows:

- Use only 7 ml or 20 ml vials. Mini (4 ml) vials or plate counters are not suitable.
- Use an absorbent material (e.g., cotton swab, alcohol wipe, kimwipe) to wipe the surface being investigated. The area of the wipe test shall be no less than 100 cm^2 (an area of 10 × 10 cm).
- A background (blank) and a reference standard must be counted along with each batch of wipe tests to ensure that the equipment is functioning properly.

Gamma Counters – With some gamma or x-ray emitting isotopes, it is preferable to use a gamma counter instead of LSC equipment. Examples of isotopes that are more readily

counted in a gamma counter are: Cr-51, I-125, Nb-95, Ru-103, Ce-141, and any isotopes utilized in microspheres (other than Y-90). The use of a gamma counter is similar to that of an LSC:

- Use an absorbent material (e.g., cotton swab, alcohol wipe, kimwipe) to wipe the surface being investigated. The area of the wipe test shall be no less than 100 cm^2 (an area of 10 × 10 cm).
- A background (blank) and a reference standard must be counted along with each batch of wipe tests to ensure that the equipment is functioning properly.

Geiger Counters – Under special conditions, a Geiger counter may be used to perform contamination surveys. The use of Geiger counters to perform surveys other than daily, non-documented monitoring is **only allowable with prior approval by the Office of Radiation Safety.** ORS will approve the use of a Geiger counter for such surveys if the following conditions are met:

- The authorized user applies to the RSC (use the Amendment Form) and receives approval.
- The use of the Geiger counter is restricted to monitoring for P-32.
- The specific instrument that is to be used must be calibrated annually and certified for use by ORS.
- Records of surveys must be maintained, the same as for other lab surveys.
- If a Geiger counter is used in an area where other isotopes are also currently in use, a wipe test must also be done.

Contamination Limits

While the occupational dose limits are 50 mSv (5000 mrem) per year, and the dose limit for members of the public is 1 mSv (100 mrem) per year, it is the goal of the MCW Radiation Safety Program to keep the dose from RAM contamination to below 0.25 mSv (25 mrem) per year. In order to maintain doses below this level, limits for surface contamination are established below:

- For laboratories performing surveys using LSCs or gamma counters that are automatically calibrated to give wipe test results in disintegrations per minute (DPM), the limit for removable surface contamination in both restricted areas and unrestricted areas is 2000 DPM/100 cm^2, unless otherwise stated as a condition of authorization by the RSC.

- For laboratories performing surveys using LSCs or gamma counters that give wipe test results in counts per minute (CPM), results must be converted to DPM. To do this, the counting efficiency (CPM/DPM) of the instrument must be determined, using a NIST-traceable calibration standard. ORS can perform this calibration. If a current calibration sticker is on the instrument, the contamination limits will be listed on the sticker.

- For laboratories using an ORS-certified Geiger counter, the contamination limit will be listed on the calibration certificate.

Decontamination

Areas where surface contamination exceeds the applicable limit, the area must be decontaminated as soon as is practical after discovery. See the Section X, "Emergency Procedures".

Instrument Calibration

Instruments used to perform surveys that document compliance with contamination limits shall be calibrated annually, or after repairs that may affect the efficiency (other than battery changes) using a NIST-traceable standard.

A suitable background (blank) and a check source to verify proper operation shall be used each time. Instruments that operate on battery power shall have a battery check prior to each use.

Instruments that are used solely for radiation detection (i.e., daily monitoring during a procedure) need not be calibrated annually, as long as each is checked for proper operation prior to use (i.e, battery and check source), and such instruments are not used to document compliance with contamination limits.

Records

- Surveys for contamination (other than the daily use of an uncalibrated portable meter) must be recorded and kept available for inspection for a period on not less than 3 years.
- Records of surface contamination must be documented in units of DPM/100 cm^2, Bq/100 cm^2 or $\mu Ci/cm^2$, unless ORS has calibrated the instrument and authorized the use of CPM.
- A map showing survey locations or a description must accompany the survey record.
- The record must contain evidence of the background count (or count rate) and the counts (or count rate) from a check source used to verify proper operation.
- When contamination is found that exceeds the applicable limit, the record must show that after decontamination was performed, the contamination levels are below the limit.

VII. Possession Limits

A. Kits for *In Vitro* Testing

The State has issued a general license to MCW and FH for the use of certain prepackaged kits, such as those used for radioimmunoassay (RIA). Strict activity limits apply to the following isotopes:

^{3}H Units not exceeding 50 μCi for each use
^{14}C Units not exceeding 10 μCi for each use

The following kits may also be used, with total possession not to exceed 200 μCi for each:

^{125}I Units not exceeding 10 μCi for each use
^{131}I Units not exceeding 10 μCi for each use
^{59}Fe Units not exceeding 20 μCi for each use
^{75}Se Units not exceeding 10 μCi for each use

NOTE: Not all purchases of isotopes in these quantities qualify as kits. Kits manufactured to meet the requirements of the general license will bear a label stating general license status.

Under the terms of the general license, certain handling requirements are exempted, contact ORS for details.

B. Broad Scope License

The FH/MCW research/medical license is of broad scope, and requires that the RSC approve individual Authorized Users with specific possession limits. Possession limits may vary as research needs change. It is requested that Authorized Users maintain possession limits current for the needs of the individual laboratory. If a project utilizing larger quantities of radioisotopes has concluded, please update possession limits to reflect the current utilization needs.

VIII. Ordering and Transferring Radioactive Material

A. Unsealed Radioactive Material

All orders for RAM must be approved by ORS before the vendor is contacted. To ensure that RAM orders are handled in a timely manner, the following procedure is provided:

Place RAM orders through Central Purchasing. **Orders arriving after 2:00 pm will not be processed until the following business day.** Be sure to include:

- Authorized User Name
- Vendor
- Catalog Number
- Isotope
- Chemical Form
- Quantity (μCi, mCi or MBq)
- Ship To Address as "Radiation Safety"

Standing Orders – When the same product is purchased frequently, or needed on a recurring schedule, set up a standing order with Central Purchasing. DO NOT PHONE IN YOUR OWN ORDERS! Individual orders on the same purchase order number must still be approved by ORS and phoned in by Central Purchasing.

Once a RAM order reaches central purchasing, the order is reviewed by ORS prior to placement. The order is then approved or disapproved according to the Authorized User's current inventory and RAM limits. If disapproved, the Authorized User will be notified as to the reason for disapproval.

If a laboratory is planning on receiving a special shipment (e.g., replacement, gratis material from a vendor, labeled items from a fellow investigator at a different institution), the ORS must be informed and approval granted before the item is shipped.

B. Sealed Sources, Irradiators

Sealed sources used in instruments (e.g., electron capture detectors) or irradiator sources must be purchased with approval from ORS. As the requirements for these sources are highly varied, check with ORS before considering purchasing such sources.

C. Calibration and Check Sources

Sealed check sources that are of exempt quantities to be used in conjunction with counters and survey equipment may be ordered without the approval of the ORS. The ORS is available to provide guidance or assistance in which sources and activities are best for your equipment.

D. Delivery of Radioactive Material

RAM packages are delivered to the MCW loading dock where they are picked up by ORS. ORS processes each RAM package by checking for contamination, damage and logging the purchase into the facility inventory. Delivery will be as soon as reasonably possible after processing. If there is no one available to receive the package, the Authorized User or laboratory personnel will be notified to contact ORS to arrange for the receipt of their RAM.

E. Transferring Radioactive Material

Transfers of RAM shall be approved by ORS prior to the transfer. Violations of this policy may result in disciplinary action against the Authorized Users involved.

Transferring to an Authorized User within MCW – ORS shall be informed of the transfer prior to transferring the RAM. ORS will need to know the nuclide, quantity, chemical form and inventory number of the material being transferred. After the transfer is approved, the new Authorized User will receive a new Material Use Sheet.

Transferring to and from Another Institution – Transfers may be made to other NRC or Agreement State licensees if prior approval is obtained from both institutions. Contact ORS for shipping and transfer procedures. NO SHIPMENTS MAY OCCUR WITHOUT ORS APPROVAL.

IX. Disposal of Low-Level Radioactive Waste

A. Waste Minimization

Authorized Users and radiation workers should be aware of the volume and activity of waste produced. Should any proposed work with RAM generate a waste that cannot be processed by the methods described in this section, contact ORS prior to beginning the project.

In all cases, whether waste is shipped for disposal or held onsite for decay, volume minimization is very important. Please survey materials to be sure that non-radioactive wastes are not unnecessarily placed in the radioactive waste.

B. Separation of Waste Types

ORS uses several methods to processes low-level waste at MCW, depending on the chemical and physical form. It is essential that labs segregate waste according to type before it is offered to ORS for disposal.

HAZARDOUS MATERIALS, LEAD SHIELDING AND UNDEFACED RADIATION STICKERS OR LABELS ARE NOT PERMITTED IN RADIOACTIVE WASTE.

C. Scintillation Fluids

High-Flashpoint (Bio-Safe) Cocktail – As a general policy, MCW allows the use of only non-hazardous liquid scintillation (LS) fluids. In some cases, low-flashpoint (toluene-xylene based) cocktails may used, but only with prior approval by ORS.

H-3 and C-14 – Liquid scintillation fluids containing only H-3 and C-14 in concentrations less than 0.05 μCi/ml must be kept separate from other scintillation fluids. The concentration is averaged over each "batch" of vials.

Isotopes with Half-Lives Less than 120 Days – LS fluids of this type can be held for decay, and must be separate from other types.

Other Isotopes or Fluids – The disposal of other long half-life isotopes or low flash-point cocktails must be arranged with ORS. These wastes are often EPA-regulated "mixed" wastes, the cost of disposal for which can be high. The Authorized User may need to bear a portion of the disposal costs.

D. Sewer Disposal

Low-level radioactive liquids may be disposed of directly to the sanitary sewer, if the following conditions are met:

- The material is readily soluble, or is readily dispersible biological material, in water.
- Radioactive liquids must be disposed in designated sinks only.
- A record must be kept of all disposals.
- The activity does not exceed the following limits:

Isotope	Activity
^{3}H	5,000 μCi
^{14}C	1,000 μCi
All Others Combined	1,000 μCi

Authorized Users may choose to transfer liquids to ORS for disposal. Such liquids must be stored in approved containers.

E. Dry, Solid RAM Waste

Lab waste contaminated with RAM that contains only dry solids, paper, plastic, gloves, glass and some metal shall be prepared for disposal and transfer to ORS.

HAZARDOUS MATERIALS, LEAD SHIELDING AND UNDEFACED RADIATION STICKERS OR LABELS ARE NOT PERMITTED IN RADIOACTIVE WASTE.

ORS provides semi-transparent yellow bags with the radiation symbol printed on the outside. Put the waste in the bag, fill out a waste tag, tie-wrap the bag closed and place it in one of the designated RAM waste lockers. ORS performs laboratory pickup of radioactive waste upon request by submitting a waste request using the online data base "EHSA".
H-3 and C-14 – These are the only two isotopes that may be combined in a single bag.

All Other Isotopes – Waste from any isotopes other than H-3 and C-14 must be placed in separate bags.

Sharps – Contaminated sharps must be stored in approved sharps containers. Contaminated sharps must be segregated according to isotope, the same as for other dry, solid waste.

F. Biological Waste

Animal carcasses or tissue containing RAM must be disposed of through transfer to ORS. Waste must be bagged, tagged, and kept frozen.

- Animal tissue containing H-3 or C-14 in quantities less than 0.05 μCi/gram, averaged over the weight of the entire tissue or carcass may be combined into the same bag.

- All other isotopes or H-3 and C-14 concentration above 0.05 μCi/gram must be bagged separately.

Due to freezer space constraints, the Authorized User should consult with ORS before starting any projects involving biological waste containing RAM. The cost of storing biological waste may be passed on to the Authorized User.

G. Mixed Hazardous and Radioactive Waste

Projects that generate hazardous waste mixed with radioactive contamination must be declared on the Application for Authorization and approved by the RSC. Contact EHS for hazardous waste criteria.

H. Waste Tags

A waste tag must be completed for every item of waste. Waste tags are part of the Environmental Health and Safety Assistant (EHSA) online database, and should be printed from a computer. For special items, contact ORS for tags. The following information must be provided:

- Authorized User name;
- Isotope;
- Activity;
- Physical form (e.g, solid, biological);
- Chemical form, if applicable for hazardous or other constituents;
- Date completed.

Waste items without a radioactive waste tag, or with incomplete information will be sent back to the Authorized User, and will not be picked up by ORS.

I. Shipping Containers, Vials

Shipping Containers – Shipping containers and the secondary containment vial holders that arrive from the vendor with RAM orders are checked for contamination upon arrival at MCW. However, it the responsibility of the Authorized User to verify boxes, cartons, shielded containers and any packing materials are not contaminated in the laboratory.

In general, shipping materials should be kept contamination-free so that they may be disposed of in the ordinary trash. Before disposal in the ordinary trash, verify that:

- A survey confirms that no radioactive contamination is present,
- All shipping labels or other markings or symbols indicating "Radioactive" or references to activity have been clearly defaced, so that a member of the public would not confuse the package for one containing radioactivity,
- All lead has been removed.

Stock Vials – When stock vials are emptied, deface the label and put the vial in with the dry, solid radioactive waste.

X. Emergencies

Emergency procedures are posted in areas where RAM is used. Radiation workers and other personnel who frequent areas where RAM is used should know where these are posted, and familiarize themselves with the procedures. The following general procedures apply to emergencies involving RAM.

A. General Instruction

1. Medical attention to an injured individual will take precedence over all other concerns. If a life or death situation occurs, a rescuer may chose to receive a maximum dose of 0.25 Sv (25 rem). Such an exposure should only be considered to save a life.
2. Do not risk radiation exposure to save equipment or an experiment. Exceptions will only be determined by a person who is qualified to estimate the potential hazard, and then exposure will be risked only after special consideration.
3. Promptly take reasonable precautions to limit the spread of the radioactive contamination. Limit access to the area(s) and limit the movement of all individuals involved in the incident.
4. Contact the MCW Office of Radiation Safety (ORS) or the FH Radiation Safety Office as soon as practical.

When a spill has occurred, estimate the amount of radioactivity spilled.
Implement a major or minor spill procedure based on the following table.

B. Spill Classification, Major or Minor

Radionuclides	Minor Spill		Major Spill
	Not Reportable	Reportable	Reportable
^{3}H, ^{14}C, ^{18}F, ^{33}P, ^{35}S, ^{47}Ca, ^{47}Sc, ^{51}Cr, ^{55}Fe, ^{57}Co, ^{67}Ga, ^{71}Ge, ^{72}Ga, $^{85,}Kr$, ^{99}Mo, ^{99m}Tc, ^{103}Pd, ^{113m}In, ^{115}Cd, ^{133}Xe, ^{141}Ce, ^{177}Lu, ^{197}Hg, ^{201}Tl, ^{202}Tl	< 1 mCi	< 100 mCi	≥100 mCi
^{22}Na, ^{32}P, ^{36}Cl, ^{42}K, ^{45}Ca, ^{46}Sc, ^{54}Mn, ^{58}Co, ^{59}Fe, ^{63}Ni, ^{65}Zn, ^{74}As, ^{75}Se, ^{85}Sr, ^{86}Rb, ^{90}Y, ^{95}Nb, ^{99}Tc, ^{103}Ru, ^{105}Ag, ^{109}Cd, ^{111}In, ^{113}Sn, ^{123}I, ^{129m}Te, ^{129}I, ^{132}Te, ^{140}Ba, ^{140}La, ^{147}Pm, ^{153}Gd, ^{192}Ir, ^{169}Yb, ^{198}Au, ^{203}Hg	< 0.1 mCi	< 10 mCi	≥10 mCi
^{60}Co, ^{125}I, ^{131}I, ^{134}Cs, ^{137}Cs, ^{144}Ce	< 0.01 mCi	< 1 mCi	≥1 mCi
^{90}Sr, ^{210}Po	< 0.001 mCi	< 0.1 mCi	≥0.1 mCi

C. Minor Spill Procedures

1. Notify personnel in the area(s) that a spill has occurred.
2. Cover the spill with a suitable absorber.
3. Follow decontamination procedures in Section E.
4. Contact the ORS as soon as practical during normal working hours.
5. If the spill is not reportable, retain survey information for later review. If the spill is reportable, submit a written report to the Radiation Safety Officer within 7 days describing the incident including actions to be taken to prevent a recurrence.

D. Major Spill Procedures

1. Notify personnel in the proximity of the spill to vacate the room(s) or area(s).
2. Cover the spill with a suitable absorber, but do not attempt to clean it up. Confine the movement of all potentially contaminated personnel to prevent the spread.
3. If possible, the spill should be shielded, but only if it can be done without further contamination or significantly increasing your radiation exposure.
4. Contact the ORS or Security immediately.
5. Secure the area(s) as practical to restrict entry.
6. If personnel contamination is found or suspected, identify the contaminated area(s) with a survey meter. Follow personal decontamination procedures in Section F.
7. Decontamination may only be performed under the direction of the ORS. Follow decontamination procedures Section E.
8. Submit a written report to the Radiation Safety Officer within 7 days describing the incident including actions to be taken to prevent the recurrence.

E. Decontamination Procedures

1. Perform appropriate surveys. Draw a floor plan indicating area(s) where surveys were performed and document the results of the surveys.
2. Wear protective clothing and use remote handling equipment as necessary or appropriate. Absorb liquids with absorbent paper or other suitable absorbent.
3. Place contaminated materials into receptacles or bags designated for radioactive waste. Decontaminate until the removable contamination is below 200 dpm per 100 cm^2 in unrestricted areas or 2000 dpm per 100 cm^2 in restricted areas. During and at the end of clean up, monitor hands, shoes, clothing and any equipment used to clean up the spill.
4. If the contamination is not removable, suitable shielding materials may be used to cover the contamination until the radiation level is reduced to less than 3 times background in a unrestricted area or 6 times background in a restricted area.

F. Personnel Decontamination Procedures

1. Remove contaminated clothing and store for further evaluation by ORS.
2. If the spill is on the skin, flush thoroughly with lukewarm water and re-survey.
3. If the contamination is still present, wet hands and apply detergent. Work up good lather and keep lather wet. Use mild soap and lukewarm water.
4. Work lather into contaminated area(s) by rubbing gently for at least 5 minutes (flush with water for at least 15 minutes when washing eyes), applying water frequently and rinse thoroughly with lukewarm water.
5. Repeat above procedures 2 through 4 several times, gently scrubbing residual contaminated area(s), as necessary.

G. Known or Suspected Overexposure to Radiation

1. Eliminate the cause of the suspected overexposure and/or prevent personnel from entering area(s) where suspected high radiation levels exist.
2. Contact the ORS or Security immediately.
3. Transport overexposed personnel to the FH Emergency Department where appropriate medical assistance can be obtained.
4. Collect and forward dosimeters to ORS for emergency processing so that dose information can be obtained as soon as practical.
5. Submit a written report to the Radiation Safety Officer within 7 days describing the incident including subsequent actions to prevent recurrence.

H. Radioactive Dusts, Fumes and Gases

1. Have personnel in the area(s) evacuate the room or area(s) as quickly as practical.
2. Seal off area(s), if practical. Secure the room or area(s) to restrict entry into the contaminated area(s). Limit the movement of all involved employees to confine the potential spread of contamination.

3. Contact the ORS or Security immediately.
4. With a low energy range, thin window GM survey meter, check hands and clothing of involved individuals for contamination.
5. Decontamination is to be performed under the direction of ORS**.**
6. Perform an air monitor survey. Work shall not be permitted in the affected room until approved by the Radiation Safety Officer.
7. Submit a written report to the Radiation Safety Officer within 7 days describing the incident including subsequent actions to prevent recurrence.

XI. Records

A. Training Records

Radiation workers training records are to be kept by each Authorized User and a copy of the training form must be sent to ORS. If a radiation worker transfers to another Authorized User, the training record will follow the worker, with the new Authorized User responsible for the training of the worker in areas specific to the new job duties. This new training must also be documented with a copy furnished to the ORS. Training documentation forms can be obtained from ORS.

B. Inventory Records

The Material Use Sheet form shall be returned to ORS upon depletion or disposal of the RAM. Quarterly inventories are to be returned to ORS within the specified time. The Authorized User is responsible for a physical check of RAM in their possession to ensure accuracy of records. If updated quarterly inventories are not returned to ORS within the allotted time, the Authorized Users ordering privileges may be withheld until the updated inventory is received by the ORS. Authorized Users who are chronically late returning inventories will be referred to the RSC.

C. Waste Disposal Records

1. Aqueous Waste into Sanitary Sewer - Release into the sanitary sewer system must be recorded. After the releases are totaled by nuclide and month, the sewer releases shall be submitted to ORS on a quarterly basis (included as part of the quarterly inventory).

2. Radioactive Waste On Hand - Each laboratory is responsible to label each container of waste generated in the lab with a radioactive waste tag, whether the radioactive waste is stored for in-lab decay or to be picked up by ORS.

D. Contamination Survey Records

Contamination survey records are to be kept for three years from the date of the last survey recorded.

E. Laboratory Audits

The ORS conducts inspections (audits) of areas where unsealed sources of RAM is used or stored on a quarterly basis. Audits normally check for:

1. Performance of contamination surveys at proper intervals and detection levels.
2. Proper laboratory procedures (e.g., storage, use and disposal of RAM).
3. Markings, labels and postings in accordance with procedures.
4. Required record keeping (e.g., waste disposal, aqueous waste, etc.).
5. Any items not in compliance with the authorization, institutional policy, state and federal regulations.
6. Other items based on current compliance trends and issues.

Exposure Type	Annual Limits for Radiation Workers		ALARA Level I (per calendar quarter)		ALARA Level II (per calendar quarter)	
	mSv	mrem	mSv	mrem	mSv	mrem
Whole Body	50	5,000	1.25	125	3.75	375
Extremity or Skin*	500	50,000	12.5	1,250	37.5	3,750
Individual Internal Organs	500	50,000	12.5	1,250	37.5	3,750
Lens of the Eye	150	15,000	3.75	375	11.25	1125
Embryo/ Fetus	5	500	0.5/month	50/month	1/month	100/month

Appendix A

Laboratory Classification Scheme

Isotope	Relative Radiotoxicity	Type 1 Lab Possession Limit (mCi)*	Type 2 Lab Possession Limit (mCi)	Type 3 Lab Possession Limit (mCi)	Type 4 Lab Possession Limit (mCi)
H-3	**1**	10	100	1000	10000
C-14	**1**	1	10	100	1000
F-18	**1**	10	100	1000	10000
Na-22	**2**	0.1	1	10	100
P-32	**2**	0.1	1	10	100
P-33	**1**	1	10	100	1000
S-35	**1**	1	10	100	1000
Cl-36	**2**	0.1	1	10	100
K-42	**1**	10	100	1000	10000
Ca-45	**2**	1	10	100	1000
Sc-46	**2**	0.1	1	10	100
Cr-51	**1**	10	100	1000	10000
Mn-54	**2**	1	10	100	1000
Fe-55	**1**	1	10	100	1000
Fe-59	**2**	0.1	1	10	100
Co-57	**2**	1	10	100	1000
Co-58	**1**	1	10	100	1000
Ni-63	**1**	1	10	100	1000
Zn-65	**2**	0.1	1	10	100
Ge-71	**1**	10	100	1000	10000
Ga-67	**1**	10	100	1000	10000
As-74	**2**	1	10	100	1000
Se-75	**2**	1	10	100	1000
Kr-85	**1**	10	100	1000	10000
Rb-86	**2**	1	10	100	1000
Sr-89	**2**	0.1	1	10	100
Sr-90/Y-90	**4**	0.001	0.01	0.1	1
Nb-95	**1**	1	10	100	1000
Tc-99m	**1**	10	100	1000	10000
Ru-103	**1**	1	10	100	1000
Pd-103	**1**	1	10	100	1000
Ag-105	**1**	1	10	100	1000
Cd-109	**3**	0.01	0.1	1	10
Cd-115	**2**	1	10	100	1000
In-111	**1**	1	10	100	1000
In-113m	**1**	0	0	0	0
Sn-113	**1**	1	10	100	1000
I-125	**3**	0.01	0.1	1	10
I-131	**3**	0.01	0.1	1	10
Xe-133	**1**	10	100	1000	10000
Te-129m	**2**	0.1	1	10	100
Ce-141	**2**	1	10	100	1000
Pm-147	**2**	0.1	1	10	100
Lu-177	**1**	1	10	100	1000
Au-198	**1**	1	10	100	1000
Hg-197	**1**	10	100	1000	10000
Tl-204	**1**	1	10	100	1000
Po-210	**4**	0.001	0.01	0.1	1
Ra-226	**4**	0.001	0.01	0.1	1
Th-232	**4**	1	10	100	1000
U-nat	**4**	1	10	100	1000
U-238	**4**	1	10	100	1000

* Except as noted in 10 CFR 33.11

For laboratories using more than one isotope, the sum of the fractions (actual possession limit: maximum possession limit) shall not exceed one.

The actual hazard of working with radionuclides is dependent on the processes performed, as well as the relative radiotoxicity. For this reason, modifying factors to the possession limits listed above are appropriate for all but Type 1 Laboratories.

Modifying factors for Types 2, 3 and 4 laboratories:		Relative Radiotoxicity:	
× 10	Simple wet operations	1	Slight
× 1	Normal chemical operations; labeling	2	Moderate
× 0.1	Complex chemical operations	3	High
× 0.1	Simple dry operations	4	Very High
× 0.01	Dry and dusty operations		

Appendix B

Annual Limit on Intake (ALI)

Annual Limit on Intake (ALI) means the maximum amount of radioactive material that can be taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year that would result in a Committed Effective Dose Equivalent of 5 rem or a Committed Dose Equivalent of 50 rem to any individual organ or tissue. ALI values for intake by ingestion and by inhalation of selected radionuclides are given below:

Isotope	ALI oral ingestion (µCi)	ALI inhalation (µCi)	Hazard Class	Isotope	ALI oral ingestion (µCi)	ALI inhalation (µCi)	Hazard Class
H-3	80000	80000	1	**Sr-89**	600	800	2
C-14	2000	2000	1	**Sr-90/Y-90**	30	20	4
F-18	50000	70000	1	**Nb-95**	2000	1000	1
Na-22	400	600	2	**Tc-99m**	80000	200000	1
P-32	600	900	2	**Ru-103**	2000	2000	1
P-33	6000	8000	1	**Pd-103**	6000	6000	1
S-35		10000	1	**Ag-105**	3000	1000	1
S-35	10000	20000	1	**Cd-109**	300	40	3
S-35	6000	2000	1	**Cd-115**	900	1000	2
Cl-36	2000	2000	2	**In-111**	4000	6000	1
K-42	5000	5000	1	**In-113m**	50000	100000	1
Ca-45	2000	800	2	**Sn-113**	2000	1000	1
Sc-46	900	200	2	**I-125**	50	80	3
Cr-51	40000	50000	1	**I-131**	30	50	3
Mn-54	2000	900	2	**Xe-133**			1
Fe-55	9000	2000	1	**Te-129m**	500	600	2
Fe-59	800	300	2	**Ce-141**	2000	700	2
Co-57	8000	3000	1	**Ce-144**	200	30	3
Co-57	4000	700	2	**Pm-147**	4000	100	2
Co-58	2000	1000	1	**Lu-177**	2000	2000	1
Co-58	1000	700	2	**Au-198**	1000	4000	1
Ni-63	9000	2000	1	**Hg-197**	7000	10000	1
Zn-65	400	300	2	**Tl-201**	20000	20000	1
Ge-71	500000	400000	1	**Tl-204**	2000	2000	1
Ga-67	7000	10000	1	**Po-210**	3	0.6	4
As-74	1000	800	2	**Ra-226**	2	0.6	4
Se-75	500	700	2	**Th-232**	0.7	0.001	4
Kr-85			1	**U-nat**	10	1	4
Rb-86	500	800	2	**U-238**	10	1	4