

Radiation Protection Procedures Manual (Authorized User Manual)

University of Cincinnati

AU MANUAL

RECORD OF REVISIONS

Revision No.	Date of Revision	Changes Entered
Original	01/01/96	None
1	2/97	Replace pages 37, 38, 61, 62, 63 and 64. Adds definition and clarifies when RAM becomes radioactive waste.
2	7/99	Revises APPENDIX VII: Point System (pages 68, 69 and 69A).
3	3/00	Updates manual for Agreement State and incorporates RSC Policy Statements.
4	11/04	Updates manual for changes in Ohio regulations and RAM waste procedures. Also, incorporated new RSC Policy Statements (03-1 and 04-1) and made changes to better standardize wording and formatting.
5	2/05	Added statement University of Cincinnati issued dosimeters cannot be used outside the RCSP. Statement added to section 8.3.
6	5/17/06	Deleted all references to The University Hospital/TUH. TUH separated from the RCSP. The effective date of the revision is 6/17/06, the effective date of the separation.
7	2/21/07	Incorporated within paragraph 3.2.1 that a UC employee of pay grade 16 of higher is qualified to be an AU. (This qualification was approved by the RSC on September 19, 2000 but was never incorporated into the manual.) Deleted the requirement in paragraph 5.5.1.3.3 that survey meters used for human use require a 6-month calibration frequency. (With 2005 regulatory changes and January 2007 license renewal, a different frequency for human use meters is no longer required.)
8	8/20/08	Modified Table 2, ALARA Investigational Levels, to delete special investigational level for the head and make equivalent to that listed in the RGE QA Manuals.
9	05/15/13	Complete review performed. Corrected typographical errors and inconsistencies noted and update Table of Contents accordingly. Major changes include (1) Applied Acronyms throughout, (2) Separated AU title requirements and AU application forms for clarity, (3) Modified backup AU examples, (4) Added where to obtain information, (5) Removed reference to CCHMC iodination facility, which no longer exists, (6) Changed authorization amendments to section level, (7) Added reference to T&R process, (8) Changed requirement regarding untrained individuals entering RAM use labs being escorted from must to should, (9) Moved noncompliance notification from posting to operation of a RAM-Use Laboratory, (10) Made requirement for checking survey meters with a RAM source more generic, (11) Added some details to the decommissioning section, (12) Added new requirement that animal

AU MANUAL

		bedding waste must be kept separate from animal tissue waste. (13) Deleted records that are unlikely to be generated by an AU/AU staff, (14) Simplified the incidents reportable to the ODH, (15) Added reference to RSC policies as applicable, (16) Reminder that shipping papers are required for shipments in motorized vehicle, (17) Removed references to misadministration and added definition of reportable dose to embryo/fetus or child, (18) Incorporated RCSP policy for declared pregnant worker.
10	2/14/14	Added Associate Radiation Safety Officer on paragraph 3.2.1.15 (ARSO) and Updated paragraph 6.6.1.2 about unsealed inventory. Added that RAM packages may be delivered by RSO staff on paragraph 6.2.4.
11	11/12/14	Updated the Dosimetry Exchange Procedures.
12	2/11/15	Updated Table 1 (action levels for removable contamination).
13	5/13/15	Updated paragraph 7.6.1.3.4. The update was prompted by ODH inspection finding.
14	5/05/21	Added note to 10.6.5.1 clarifying bioassay requirements for those present with encapsulated I-131 administration.
15	8/04/21	Changed the RSO audit frequency from semiannually to annually. Modified document to meet ADA compliance. Updated hyperlinks as appropriate.
16	1/25/22	Improved ADA compliance. Aligned training statements with RSC Policy Statement 20-1 RAM Training.

TABLE OF CONTENTS

1. PURPOSE AND SCOPE.....	9
2. RADIOACTIVE MATERIAL (RAM) USE PROCEDURES.....	10
3. ESTABLISHING AN AUTHORIZATION TO USE RAM.....	10
3.1. User Qualifications.....	10
3.1.2. Qualifications for Authorized User (AU) Non-Human Use.....	10
3.1.3. Qualifications for Authorized User (AU) Human Use-Clinical.....	10
3.1.4. Qualifications for Authorized User (AU) Human Use-Investigational.....	11
3.2. Notifications.....	11
3.3. Application.....	11
3.4. AU and Site-Specific Training.....	12
3.5. RSO Interview.....	12
3.6. Facility Evaluation.....	12
3.7. Approval of AU Application by RSC.....	13
4. AMENDING A RAM AUTHORIZATION.....	13
4.2. Amendments to existing authorizations, except decommissioning of RAM use area(s).....	13
4.3. Amendments involving decommissioning RAM use area(s).....	13
5. QUALIFYING A RAM RADIATION WORKER (RAM RW).....	14
5.3. Training Record Maintenance.....	15
6. RAM CONTROL "CRADLE TO GRAVE".....	16
6.1. Purchase of RAM.....	16
6.2. Receipt of RAM.....	16
6.3. Transfer of RAM.....	18
6.3.1. Internal transfer of RAM (within UC's license).....	18
6.3.2. External transfer of RAM (outside UC's license).....	18
6.3.3. RAM Waste Procedures.....	19
6.4. Storage of Radioactive Material (RAM).....	19
6.5. Transport of Radioactive Material (RAM).....	19
6.6. Inventory of Radioactive Material (RAM).....	20
6.7. Special Requirements for Sealed Sources.....	21
7. OPERATION AND MAINTENANCE OF A RAM-USE LABORATORY.....	21
7.1. Commissioning an Area of Use.....	21
7.2. Decommissioning an Area of Use.....	21
7.3. Posting of RAM Laboratories.....	22
7.4. Notification of Non-compliances and/or Areas of Concern.....	23
7.5. Maxims of Good Radiation Laboratory Practice.....	23
7.6. Radiation Laboratory Monitoring.....	25
7.6.1. Use of Survey Meters.....	25

AU MANUAL

- 7.6.2. Surveying Unsealed Source Use Areas for Removable Contamination (“wipe test”)26
- 7.6.3. Routine Surveys27
- 7.7. Laboratory Emergency Procedures28
- 8. RSO of INSPECTIONS, SURVEYS, AUDITS AND NON-COMPLIANCE ASSESSMENT.... 28**
- 8.1. Non-human Use Authorization Inspections28
- 8.2. Human-use Authorization Inspections29
- 8.3. Non-human Use Compliance Assessment (Point System)29
- 8.4. Special Rules for Retraining31
- 8.5. Applying RCSP Rules to Visitors and Ancillary Staff31
- 9. PERSONNEL PROTECTION..... 32**
- 9.1. Time, Distance and Shielding32
- 9.2. Internal Contamination Prevention33
- 9.3. The Declared Pregnant Worker33
- 10. PERSONNEL MONITORING 34**
- 10.1. Dosimetry Requirements34
- 10.2. Dosimetry Exemptions34
- 10.3. Care and Use of Dosimeters35
- 10.4. Dosimetry Analysis and Reports35
- 10.5. ALARA Investigations36
- 10.6. Bioassay37
- 10.6.4. Tritium Bioassays37
- 10.6.5. Iodine Bioassays37
- 11. PERSONAL PROTECTIVE EQUIPMENT (PPE) 38**
- 11.3.1. Lab coat39
- 11.3.2. Gloves39
- 11.3.3. Eye Protection39
- 11.3.4. Respiratory Protection40
- 12. DECONTAMINATION PROCEDURES 40**
- 12.1.1. Personnel Decontamination40
- 12.1.2. Equipment and Materials Decontamination41
- 13. WASTE HANDLING AND DISPOSAL 42**
- 13.1. General Information42
- 13.2. Requesting a Waste Pickup and/or Supplies43
- 13.3. Radioactive Waste Separation43
- 13.4. Waste Packaging45
- 13.4.2. Solid (combustible (CS) and noncombustible (NS)) Waste45
- 13.4.3. Non-hazardous Bulk Liquids (SL)46
- 13.4.4. Mixed Waste (HL)48

AU MANUAL

13.4.5.	Liquid Scintillation Vials (SV)	49
13.4.6.	Pathological Waste (PT) Solids.....	50
13.4.7.	Pathological Waste (PT) Liquid.....	52
13.4.8	Infectious Waste (IW) Liquid	53
13.4.9	Infectious Waste (IW) Solids Half-life \leq 120 days	55
13.4.10	Infectious Waste (IW) Solids Half-life $>$ 120 days.....	56
13.4.11	Packaging instructions for sharps and sharp objects.....	57
13.5	Recycled Lead	57
13.6.	Uranium and Thorium Waste	58
13.7.	Old RAM Waste in Laboratory	58
13.8.	Record-Keeping for Radioactive Waste	58
13.8.1.	Radioactive Waste Container Log Sheet.....	58
13.8.2.	Radioisotope Use Record Card	59
13.8.3.	Waste Estimate Tag.....	59
13.9.	Equipment Release Surveys	59
14.	RECORDKEEPING AND REPORTS.....	60
14.1.	General Records and Retention Times	60
14.2.	Incident Reports.....	61
14.2.1.	AU Responsibility to Report.....	61
14.2.2.	Categories of Incidents Requiring RSO of Notification	61
14.2.3.	Categories of Incidents Requiring ODH Notification.....	62
15.	LABORATORY EMERGENCY PROCEDURES	62
15.1.	RSO Authority	62
15.2.	Emergency Plan.....	63
15.3.	Sample Emergency Procedures	63
15.4.	Accidental Spills Procedure.....	63
15.5.	Spill Reported Late.....	65
15.6.	Laboratory Fire Emergency Procedures	65
15.7.	Skin Contamination	66
15.8.	Internal Contamination	66
15.9.	Medical Emergencies Involving RAM.....	67
	APPENDIX I: LIST OF RADIATION SAFETY FORMS.....	68
	APPENDIX II: GLOSSARY OF TERMS.....	69
	APPENDIX III: RULES OF THUMB.....	74
	APPENDIX IV: DEFINITION OF MEDICAL EVENT AND REPORTABLE DOSE TO EMBRYO/FETUS OR NURSING CHILD	75
	APPENDIX V: POINT SYSTEM.....	76

AU MANUAL

APPENDIX VI: PERSONNEL DECONTAMINATION METHODS..... 80
APPENDIX VII: EQUIPMENT/PROPERTY DECONTAMINATION METHODS 81

List of Tables

Table 1 - Action Levels for Removable Surface Contamination.....26
Table 2 - Audit Assessment Criteria.....29
Table 3 - ALARA Investigational Levels.....36
Table 4 - Activity Levels Above Which Bioassays for I-125 or I-131 are Necessary38
Table 5 - Half-Life Classifications44
Table 6 - Physical/Chemical Form Classifications44
Table 7 - Solid PT Waste Bag Activity Limits51
Table 8 - Reportable Quantities of Common Radionuclotides62

List of Figures

Figure 1 - Waste Pail.....45
Figure 2 – Various Carboys47

Abbreviations and Acronyms

Abbreviation/Acronym	Definition
AAPM	American Association of Physicists in Medicine
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit on Intake
AMP	Authorized Medical Physicist
AU	Authorized User
CFR	Code of Federal Regulations
CCHMC	Cincinnati Children's Hospital Medical Center
CPM	Counts Per Minute
DOT	United States Department of Transportation
DPM	Disintegrations Per Minute
EDS	Eating, drinking, and smoking
HDR	High Dose Remote Afterloader
IACUC	Institutional Animal Care and Use Committee
IAEA	International Atomic Energy Agency
IBC	Institutional Biosafety Committee
IRB	Institutional Review Board
NCRP	National Council on Radiation Protection
NRC	United States Nuclear Regulatory Commission
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
ODH	Ohio Department of Health
ORC	Ohio Revised Code
OSL	Optically Stimulated Luminescence dosimeter
PPE	Personal Protective Equipment
QA	Quality Assurance
QMP	Quality Management Program
RAM	Radioactive Material
RCRA	Resource Conservation and Recovery Act
RCSP	Radiation Control and Safety Program
RDRC	Radioactive Drug Research Committee
RGE	Radiation Generating Equipment
RS	Radiation Safety
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
RSOf	Radiation Safety Office
RW	Radiation Worker
SHC	Shriners Burns Hospital for Children
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent Dosimeter
UC	University of Cincinnati

AU MANUAL

1. PURPOSE AND SCOPE

- 1.1. The purpose of this manual is to supplement the Radiation Control and Safety Program Manual (RCSP Manual).
- 1.2. This manual is intended to provide both general and specific instructions to AUs and their supervised RAM RWs in the safe handling of RAM, including the control of personnel radiation exposures, area access, and internal exposure.
- 1.3. This manual is a compilation of relevant rules and regulations, policies, guidelines, procedures and tables to be used as a daily reference for the safe operation of laboratories or other areas where RAM is used and/or stored.
- 1.4. All policies and procedures contained within this manual are offered to assure compliance with applicable regulations contained in rules enacted by the ODH, and specific conditions of UC's broad scope license to possess and use RAM.
 - 1.4.1. Current copies of rules, regulations and the license are maintained in the RSO of.
 - 1.4.2. Current copies of regulations are available on the ODH website at <https://codes.ohio.gov/ohio-administrative-code/3701:1>
- 1.5. For those individuals involved in human-use RAM procedures, the following additional guidance is offered.
 - 1.5.1. Routine clinical human-use applications are to be addressed in departmental policy and procedures manuals with specific guidance offered in ODH rules and the conditions of UC's ODH Type A broad scope license.
 - 1.5.2. Non-routine or investigational human-use RAM applications are also subject to review and approval by the appropriate IRB and, when applicable, an RDRC. An integral part of the IRB review process is a protocol review by the RSC. The RSC review entails a thorough review of the radiation safety aspects of the proposed use in regard to radiation exposure for personnel and the general public.
 - 1.5.3. The medical uses of radiopharmaceuticals and sealed sources for human-use diagnostic and therapeutic procedures are governed by regulations contained in ODH rules (e.g., OAC 3701:1-56) and UC's ODH Type A broad scope license conditions specifically addressing human-use.
 - 1.5.4. To closely monitor the human uses of RAM, the Department/Division of Nuclear Medicine, Radiation Oncology and/or Radiology will be audited by RSO of representatives on a quarterly basis. (Contact the chair of the referenced departments/divisions or the RSO of for additional information.)
- 1.6. For those individuals involved in RAM procedures that also involve the use of animals and biohazardous agents.
 - 1.6.1. The use of animals is also subject to review and approval of the appropriate IACUC. A part of IACUC review may include a review by the RSO of to ensure the proposed use of RAM has been approved by the RSC and there are waste disposal outlets available.
 - 1.6.2. The use of biohazardous agents is also subject to review and approval of the IBC. A part of the IBC review may include a review by the RSO of to ensure there are waste disposal outlets available.

AU MANUAL

2. RADIOACTIVE MATERIAL (RAM) USE PROCEDURES

- 2.1 Before any RAM may be purchased, received, or used under the RCSP a UC authorization to use RAM must be established. The RCSP covers ionizing radiation usage at UC campuses, CCHMC, SHC and Hoxworth Blood Center.

3. ESTABLISHING AN AUTHORIZATION TO USE RAM

3.1. User Qualifications

- 3.1.1. To establish an authorization, the AU applicant must meet qualifications for proposed use and complete the application process outlined in the following paragraphs.

3.1.2. Qualifications for Authorized User (AU) Non-Human Use

3.1.2.1. Have ties to UC as follows:

- 3.1.2.1.1. A full-time faculty member at UC or a full-time faculty member at CCHMC, paid or unpaid by UC or a full-time faculty member at SHC, paid or unpaid by UC, or a full-time faculty member at the Hoxworth Blood Center paid or unpaid by UC, or emeritus professor at one of the above institutions with AU status at the time of emeritus appointment or
- 3.1.2.1.2. A full-time paid employee (UC, CCHMC, SHC or Hoxworth Blood Center) holding the rank of UC Research Associate or Research Scientist, with or without parenthetical rank or
- 3.1.2.1.3. A full-time paid employee of UC having a pay grade 16 or higher or
- 3.1.2.1.4. A full-time faculty position at UC and paid by an institution under contract/affiliation with UC, or
- 3.1.2.1.5. An individual named Radiation Safety Officer (RSO), Associate Radiation Safety Officer or Assistant Radiation Safety Officer (ARSO) for UC.

3.1.2.2. Possess and document training and experience as required by the RSC. These requirements include as a minimum the following:

- 3.1.2.2.1. A college degree at the bachelor level, in the physical or biological sciences or in engineering; or equivalent training and experience, and
- 3.1.2.2.2. At least 40 hours of training and/or experience in the safe handling of RAM, and in the characteristics of ionizing radiation, units of radiation dose and quantities, radiation detection instrumentation, and biological hazards of exposure to the type(s) and form(s) of RAM to be used. (Note: 1-year hands-on research use is considered equivalent to 40 hours experience.)

3.1.3. Qualifications for Authorized User (AU) Human Use-Clinical

- 3.1.3.1. Be qualified according to the criteria in the applicable part(s) of ODH rule.
- 3.1.3.2. Be board certified or eligible in Diagnostic Radiology, Radiation Therapy, or Nuclear Medicine.
- 3.1.3.3. Have credentials approved by the hospital (e.g., CCHMC, or SHC) and by the Department/Division Director of Radiology, Radiation Oncology, or Nuclear Medicine for the specific clinical use.

AU MANUAL

- 3.1.3.4. Be licensed to practice medicine in the State of Ohio.
- 3.1.4. Qualifications for Authorized User (AU) Human Use-Investigational
 - 3.1.4.1. Contact the RSO for instructions, in addition to meeting the following requirements.
 - 3.1.4.2. Meet the qualifications for an AU human use-clinical, as described in 3.1.3. above.
 - 3.1.4.3. Have the proper approvals of the appropriate IRB and, when applicable, an RDRC.
- 3.2. Notifications
 - 3.2.1. Notify the RSO of the intent to apply for AU status, obtain an AU packet, and make an appointment with the RSO to review your application and past experience with RAM.
- 3.3. Application
 - 3.3.1. Submit the appropriate application form(s) and associated documentation to the RSO in advance or at the time of the RSO interview (see Section **3.5** below for interview details).
 - 3.3.1.1. Non-human use (e.g., bench/animal research): RS Form 6, "APPLICATION FOR NON-HUMAN USE OF RADIOACTIVE MATERIAL "Human use not requiring IRB review/approval: RS Form 30, "APPLICATION FOR CLINICAL HUMAN USE OF RADIOACTIVE MATERIAL"
 - 3.3.1.2. Human use requiring IRB review/approval: RS Form 31, "APPLICATION FOR INVESTIGATIONAL HUMAN USE OF RADIOACTIVE MATERIAL"
 - 3.3.2. The Department or Division Head's signature must be on the application form(s) indicating approval has been granted by the department or division.
 - 3.3.2.1. For RS Form 6 applications, the associated documentation includes:
 - 3.3.2.1.1. Preparing an emergency plan (or indicate intent to use the general plan summarized on RS Form 34, "EMERGENCY PROCEDURES – INCIDENTS INVOLVING RADIOACTIVE MATERIAL") as outlined in Section **13** of this manual which incorporates or references lab-specific procedures to be implemented in the following emergency situations.
 - 3.3.2.1.1.1. Spill of radioactive material
 - 3.3.2.1.1.2. Large fire
 - 3.3.2.1.1.3. Small fire
 - 3.3.2.1.1.4. Internal contamination
 - 3.3.2.1.1.5. Medical emergency
 - 3.3.2.1.2. If desired, designating a Backup (secondary) AU with the following qualifications. (A Backup (secondary) AU is required if RAM will be used when the AU is out-of-town. A Backup (secondary) AU is an individual who can act as an on-site supervisor in case of emergency when the AU is out-of- town. Designation of a Backup (secondary) AU in no way diminishes the AU's responsibility.)
 - 3.3.2.1.2.1. Meets all the qualifications of an AU listed in Section **3.1** of this manual.
 - 3.3.2.1.2.2. Is approved as an AU for the proposed use classification (e.g., bench research, irradiator use) by the RSC.

AU MANUAL

- 3.3.2.1.3. Providing documentation of past training and experience as required by the RSC. The minimum documentation required is a completed RS Form 6.1, "STATEMENT OF PRIOR TRAINING AND EXPERIENCE" and verification of past experience (e.g., preceptor statement or authorization from another institution) or prior training (e.g., training certificate).
- 3.3.2.2. For RS Form 30 and 31 applications, the associated documentation includes:
 - 3.3.2.2.1. Providing documentation of past training and experience as required by the RSC. The minimum documentation required is:
 - 3.3.2.2.1.1. Completion of RS Form 30 Appendix A,
 - 3.3.2.2.1.2. Verification of certification for applicable specialty, as applicable, and
 - 3.3.2.2.1.3. Verification of state of Ohio medical license.
- 3.4 AU and Site-Specific Training
 - 3.4.1 AU Training and Preparation
 - 3.4.1.1 Prior to the appointment with the RSO (see Section 3.5 below), complete AU training.
 - 3.4.1.1.1 Obtain and review copies of the Radiation Worker Training Manual, the Radiation Control and Safety Program Manual and the Radiation Protection Procedures Manual (Authorized Users Manual). (Copies are included in the AU packet. Copies are also available on the Radiation Safety website <https://research.uc.edu/support/offices/radsafety/overview> or from the RSO of.)
 - 3.4.1.1.2 Review the AU training film. (Available on the Radiation Safety website <https://research.uc.edu/support/offices/radsafety/overview> or from the RSO of.)
 - 3.4.2 Site-Specific Training
 - 3.4.2.1 Successfully complete UC's site-specific RAM RW training program.
 - 3.4.2.2 Site-specific training must be completed prior to RAM use authorization approval.
- 3.5 RSO Interview
 - 3.5.1 Set an appointment with the RSO to review the applicable authorization application form(s).
 - 3.5.2 During the RSO interview, your applicable authorization application form(s) (preferably completed), your experience, and the facility and administrative controls in place (or to be put in place) in the laboratory that will assure the licensed material is used safely, will be reviewed.
 - 3.5.3 During the RSO interview, questions concerning the roles and responsibilities of the AU, RAM RWs, the RSC, and the RSO of will be answered and clarified.
- 3.6 Facility Evaluation
 - 3.6.1 Commissioning
 - 3.6.1.1 After submission of the applicable authorization application form(s) and RSO interview, arrangements will be made for the RSO of to perform a facility evaluation and, if a current or prior RAM use area, a baseline radiation contamination survey of the area(s) in which RAM has been requested to be used.
 - 3.6.1.2 Unless specifically approved in writing by the RSO, iodination procedures (and other

AU MANUAL

experimental procedures which potentially generate volatile radioiodine) must be performed in the Radiation Safety Laboratory Iodination Facility, or another approved iodination facility. The facility(s) to be used must be specifically requested on the authorization application.

3.7 Approval of AU Application by RSC

- 3.7.1 Upon successful completion of the above requirements, the RSO will seek approval of the application(s) by the RSC at its next meeting.
- 3.7.2 On a case-by-case basis, temporary approval may be granted by an RSC executive committee pending review/approval by the full RSC at its next meeting.
- 3.7.3 Carefully review the initial authorization when it is received from the RSO to ensure all requested items were correctly incorporated into the authorization and there is a clear understanding of any conditions incorporated into the authorization.

4. AMENDING A RAM AUTHORIZATION

- 4.1. Notify the RSO, preferably at least 30 days in advance, of intent to amend a RAM authorization.
 - 4.1.1. Amendments are processed as quickly as practical, which generally is less than 30 days; however, some amendments may take longer.
 - 4.1.2. Amendments that require a modification of UC's license will likely take 90 days or more and may require the AU to pay any associated license amendment fees.
- 4.2. Amendments to existing authorizations, except decommissioning of RAM use area(s)
 - 4.2.1. Shall be submitted on RS Form 6, 30, or 31, as appropriate.
 - 4.2.2. Complete only applicable sections and provide only applicable information that applies to the amendment request, along with the applicant's signature and Department or Division Head's signature.
 - 4.2.3. Examples of amendments include adding new radionuclides, increasing order or possession limits, adding new areas of use, adding additional laboratory space, and changing or adding general purposes of use or experimental procedures.
 - 4.2.4. Some amendments require RSC approval. These include but are not limited to amendments adding a new radionuclide, and amendments increasing the order or possession limits. On a case-by-case basis, temporary approval may be granted by an RSC executive committee pending review/approval by the full RSC at its next meeting.
- 4.3. Amendments involving decommissioning RAM use area(s)
 - 4.3.1. An AU may request to have an area of use (e.g., laboratory) decommissioned due to termination of employment, transfer of a laboratory space, or discontinuation of use of RAM. In addition, the RSC and the RSO may determine an area of use should be decommissioned for cause (e.g., construction or significant non-compliances).
 - 4.3.2. To prepare an area of use for decommissioning, the AU must do the following.
 - 4.3.2.1. Ensure all RAM has been removed from the area of use including RAM waste material. **DO NOT REMOVE RADIATION WARNING SIGNS OR POSTING.**
 - 4.3.2.2. Ensure Complete and document a final survey of the area of use. Submit the survey

AU MANUAL

documentation, along with an appropriately completed RS Form 24, “DECOMMISSIONING OF RAM-USE ROOM” to the RSO.

- 4.3.2.2.1. Upon receipt of the RS Form 24, the RSO will conduct a confirmatory decommissioning survey of the area of use.
- 4.3.2.2.2. If contamination is detected, the AU will be expected to decontaminate the area of use before a resurvey is performed by the RSO, and before the area of use can be released from AU responsibility.
- 4.3.2.2.3. The AU is responsible for removing any RAM contamination before the area of use is decommissioned. In cases where the contamination cannot be removed before the AU leaves, the responsibility for decontamination transfers to the Department/Division Chair. The Department/Division Chair must add the area of use to their authorization, become an AU and include the area of use under their authorization, have the area of use added to the authorization of an AU willing to accept the contamination and associated responsibility, or become a responsible administrator as outlined in RSC Policy 07-2. (Copy of RSC Policy 07-2 is available on the Radiation Safety website <https://research.uc.edu/support/offices/radsafety/overview> from the RSO.)
- 4.3.3. The RSO will notify the AU of the successful decommissioning of an area of use and remove RAM room warning signs and/or postings. Until such time as notification is received, all RAM use area rules apply to the area and the AU remains responsible for activity within the area.
- 4.4. Carefully review each authorization amendment when it is received from the RSO to ensure all requested changes were correctly incorporated into the authorization and there is a clear understanding of any conditions incorporated into the authorization.

5. QUALIFYING A RAM RADIATION WORKER (RAM RW)

- 5.1 Only RAM RWs may handle RAM. Individuals are not considered RAM RWs until all required training and documentation is completed, and all required documentation is submitted to the RSO.
- 5.2 All RAM RWs are assigned to work under the supervision of an AU (or multiple AUs). For each RAM RW, the AU shall do the following.
 - 5.2.1 Obtain a copy of UC's RW Training Manual for review by the proposed RAM RW. (Copy available on the Radiation Safety website <https://research.uc.edu/support/offices/radsafety/overview>)
 - 5.2.2 Arrange for the proposed RAM RW to attend UC's site-specific training courses given by the RSO.
 - 5.2.2.1 Site-specific training includes both the “Basic” and “Advanced” courses.
 - 5.2.2.2 The course schedule is available on the Radiation Safety website <https://research.uc.edu/support/offices/radsafety/overview>
 - 5.2.2.3 A training certificate is provided to each individual who successfully completes site-specific training.
 - 5.2.3 Verify the AU approves the prospective RAM RW to work under their supervision. Verification is documented by signing and dating the applicable line of section 1, Applicant's

AU MANUAL

Use Category on RS Form 2.0, "RADIATION WORKER/DOSIMTERY APPLICATION."

- 5.2.4 Ensure the proposed RAM RW has provided the RSO of authorization to obtain a complete occupational radiation exposure history (i.e., complete section 3, Previous Radiation Source Experience/Training of RS Form 2.0.)
- 5.2.5 Ensure all (male and female) RAM RWs have reviewed and understand Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure". (Note: This regulatory guide is reviewed during site-specific training required.)
- 5.2.6 Conduct and document laboratory specific training. Laboratory specific training must include the AU reviewing with the RAM RW the following items (RS Form 2.1, "DOCUMENTATION OF AU LAB SPECIFIC RADIATION WORKER TRAINING/INTERVIEW" may be used to document laboratory specific training):
 - 5.2.6.1 Previous training and/or experience in radiation safety and use of RAM.
 - 5.2.6.2 RAM used under the authorization and its relative hazards.
 - 5.2.6.3 Procedures for safe use of RAM.
 - 5.2.6.4 Emergency plans and procedures in effect for RAM.
 - 5.2.6.5 The AU's authorization to use RAM and any recent non-compliances and the associated corrective action.
- 5.2.7 If the RAM RW will operate an irradiator or requires unescorted access to an irradiator facility, the RAM RW must complete the "Trustworthy and Reliable" process. Contact the RSO for details.
- 5.2.8 After successful completion of the training requirements, and upon receipt of the appropriate personnel dosimeter (if required), the worker may use RAM under the supervision of the AU.
- 5.2.9 To maintain RAM RW status, each RAM RW must attend at least one radiation safety training session annually. These sessions will be provided through the RSO.
- 5.2.10 To reestablish RAM RW status, an individual must be up-to-date on their RAM training.
 - 5.2.10.1 Individuals who last attended site-specific training or an appropriate retraining session three (3) years ago or less may bring their training status up-to-date by attending a site-specific or an appropriate retraining course.
 - 5.2.10.2 Individuals who last attended site-specific training or an appropriate retraining session over three years ago must bring their training status up-to-date by attending site-specific training.
- 5.3 Training Record Maintenance
 - 5.3.1 The AU must maintain a copy of all AU laboratory specific training conducted. It is recommended a copy be sent to the RSO.
 - 5.3.2 The AU must maintain training records of RAM RW as long as an individual is listed as a RAM RW under the authorization.
 - 5.3.3 The RSO will maintain a file for each RAM RW containing documentation of all site-specific training, retraining, and/or any RSO of conducted special training attended. This file may also be used for other documentation, such as RS Form 2.0s, bioassay reports,

AU MANUAL

dosimetry reports, and other correspondence relating to the RAM RW.

- 5.4 Persons under the age of 18 (minors) are bound by more restrictive regulations governing allowable exposure limits, and in general must be escorted while in RAM use areas. Contact the RSO of for additional information.

6. RAM CONTROL "CRADLE TO GRAVE"

6.1. Purchase of RAM

- 6.1.1. All orders of RAM, including reorders due to receipt of poor quality RAM, may NOT be directly ordered from a vendor without prior approval from the RSO of.
- 6.1.2. To obtain RAM, the purchaser or recipient must be an approved AU.
- 6.1.3. All purchase/receipt requests from a vendor or outside institution must be submitted on an RS Form 14, "RADIOACTIVE MATERIAL REQUEST".
- 6.1.4. The RS Form 14 must include the authorization number, the AU's name, the number of items and activity per item ordered, the radionuclide, the chemical form, and the catalog number of the requested RAM. A contact person must be included for notification of receipt and/or for questions regarding any problems with the order.
- 6.1.5. All RS Form 14s must be reviewed by the RSO of for approval prior to order or receipt of RAM. (Standing orders may be used; however, approval of the original standing order, changes to the standing order involving RAM (radionuclide or activity) and standing order renewals must be approved by the RSO of. Renewal of RSO of approval for standing orders is required one year after the date of last approval.)
- 6.1.6. Each supplier of RAM is required by federal and state regulations to verify the UC license to possess and use such material. The RSO of will arrange for copies of the appropriate documentation to be made available to each supplier. If a supplier indicates they do not have a copy of the applicable license, contact the RSO of and a copy will be sent.
- 6.1.7. All shipments of RAM must be delivered to the RSO of or to areas (e.g., human-use) specifically approved by the RSC.
 - 6.1.7.1. If the RAM is delivered to the RSO of, following verification the terms of the authorization and the approved order have been satisfied, the RSO of will notify the AU's laboratory the RAM may be delivered by the RSO of staff or may be picked up by the AU or designee.
 - 6.1.7.2. If RAM is delivered directly to an AU/AU laboratory by mistake, the RSO of must be notified immediately.
- 6.1.8. The RAM inventory must be maintained and updated as indicated in Section 6.6 of this manual.

6.2. Receipt of RAM

- 6.2.1. The RSO of will monitor, upon receipt at the RSO of, the outside of all packages containing RAM for removable contamination and radiation levels. (For areas where direct shipment was approved by the RSC, AU/AU staff must perform a survey of the outside of each package received and the RSO of will audit package receipt surveys.)
- 6.2.2. RAM contained in DOT shipping containers does not require the wearing of Personal Protective Equipment (PPE) when handled.

AU MANUAL

- 6.2.3. RAM packages labeled as YELLOW II or YELLOW III and having a surface radiation level exceeding 0.005 mSv/hr (0.5 mrem/hr) must be transported on a cart or in such a manner that the package can be held away from the individual transporting it. (Carrying these packages without utilizing distance, does not keep doses ALARA.)
- 6.2.4. RAM packages will be delivered by RSO of staff or may be picked up at the RSO of by the AU or an individual designated in writing by the AU. Any of the following are acceptable methods for designating an individual. (Refer to RSC Policy 98-1.)
 - 6.2.4.1. Any RAM RW listed under the AU's authorization.
 - 6.2.4.2. A list of individuals provided to the RSO with the following information.
 - 6.2.4.2.1. Signature of the AU and date signed.
 - 6.2.4.2.2. The following statement or equivalent, "The following individual(s) are authorized to pickup radioactive material packages received in the RSO of under my authorization."
 - 6.2.4.3. A list of other AUs whose RAM RWs are authorized to pickup RAM packages provided to the RSO with the following information.
 - 6.2.4.3.1. Signature of the AU and date signed.
 - 6.2.4.3.2. List the delegated AU(s) with their signatures.
 - 6.2.4.3.3. The following statement or equivalent, "All radiation workers under the following AU(s) authorization(s) are authorized to pickup radioactive material packages received in the RSO of under my authorization. It is understood I have the ultimate responsibility for actions taken by these individuals during transportation of the radioactive material."
 - 6.2.4.4. A letter presented at the time of pickup with the following information.
 - 6.2.4.4.1. Signature of the AU.
 - 6.2.4.4.2. A statement the individual is authorized to pickup RAM packages for the AU.
 - 6.2.4.5. Designating the individual as the contact person on the RS Form 14.
- 6.2.5. RSO of personnel will perform the following when an individual requests to pick up a RAM package.
 - 6.2.5.1. Ask the individual their name, the AU's name and the radionuclide of the RAM to be released.
 - 6.2.5.2. Verify the individual is approved by any of the methods above by the AU to pick up the RAM package.
 - 6.2.5.3. Have the individual sign and date the RS Form 14.
- 6.2.6. The AU or designated RAM RW must monitor the internal packaging when opening packages.
 - 6.2.6.1. Verification package content are as expected, and monitoring of the internal packaging material must be performed promptly upon transport to the laboratory.
 - 6.2.6.2. Proper protective clothing and appropriate dosimetry must be worn, including at a minimum a lab coat and gloves.
 - 6.2.6.3. Packages should be opened in a fume hood, if one is available. (Laboratories that use

AU MANUAL

volatile chemicals containing RAM are required to have a fume hood available.)

- 6.2.6.4. Check the entire package for evidence of damage or breakage.
- 6.2.6.5. All packaging material must be checked for contamination with instrumentation appropriate for the radionuclide received.
- 6.2.6.6. Packaging material, as well as the outside of the container housing the RAM, must be wipe tested for loose contamination and checked with an appropriate counting device (e.g., liquid scintillation counter or gamma counter).
- 6.2.6.7. If there is any evidence of leakage or external contamination, the RSO of must be contacted immediately.
- 6.2.6.8. Once it has been determined no contamination exists on packaging materials and before the packaging materials may be disposed of as regular trash, any trefoil warning labels must be removed and obliterated, or be completely defaced to prevent anyone from mistakenly identifying the material as being radioactive.

6.3. Transfer of RAM

6.3.1. Internal transfer of RAM (within UC's license).

- 6.3.1.1. Unless specifically exempted as a condition under an authorization to use RAM, the following must be performed for each internal transfer of RAM.
 - 6.3.1.1.1. Before performing an internal transfer of RAM (within UC's license), complete RS Form 10A, "RAM TRANSFER REQUEST" and forward to the RSO of.
 - 6.3.1.1.2. The RS Form 10A must be signed by the transferring AU, the receiving AU, and the RSO before the transfer may proceed.
 - 6.3.1.1.3. Refer to RSC Policy 98-2 and Section 6.5 of this manual for information regarding transport of RAM.
 - 6.3.1.1.4. The RSO of will notify the transferring AU if shipping papers are required. Shipping papers are required if the RAM will be transported using a motorized vehicle.
- 6.3.1.2. The AU inventory must be updated to reflect these transfers.

6.3.2. External transfer of RAM (outside UC's license).

- 6.3.2.1. Unless specifically exempted in writing by the RSO, the following must be performed for each external transfer of RAM.
 - 6.3.2.1.1. Before performing an external transfer of RAM (outside of UC licensed facilities) notify the RSO of using RS Form 10A, "RAM TRANSFER REQUEST".
 - 6.3.2.1.2. The RS Form 10A must include the license number of the receiving facility, and the name and phone number of a contact person at the receiving facility before the transfer may proceed.
 - 6.3.2.1.3. Unless transport across public road(s) in a motorized vehicle is required (e.g., West Campus to East Campus by car or van) the package must be brought to the RSO of for transfer. This includes shipments of "Exempt Quantities" of RAM. If transport of the package to the RSO of requires crossing public road(s) in a motorized vehicle or the package cannot be brought to the RSO of, arrangements shall be made with the RSO of to prepare the package for shipment at the AU's laboratory. (Refer to RSC Policy 98-2 and Section 6.5 of this manual for information regarding transport of RAM.)

AU MANUAL

- 6.3.2.1.4. The RSO of will ensure the shipment is performed in accordance with DOT regulations and ODH rules.
- 6.3.2.2. The AU inventory must be updated to reflect these transfers.
- 6.3.3. RAM Waste Procedures
 - 6.3.3.1. Refer to Section **13** of this manual, WASTE HANDLING AND DISPOSAL, for complete details of radioactive waste procedures.
 - 6.3.3.2. AU/AU staff must ensure radioactive waste is properly segregated from non- radioactive waste.
 - 6.3.3.3. AU/AU staff are not authorized to dispose of RAM via the sewer, by decay- in-storage or by any other method except through the RSO of, unless specifically approved in writing on the AU's authorization.
 - 6.3.3.4. Material is considered RAM if radiation is detectable at 100 CPM above background using appropriate detection instrumentation.
- 6.4. Storage of Radioactive Material (RAM)
 - 6.4.1. Store RAM in a manner that provides the following.
 - 6.4.1.1. Proper identification
 - 6.4.1.1.1. Identification as RAM (i.e., a "Caution-Radioactive Material label").
 - 6.4.1.1.2. Identification of activity, radionuclide and chemical form.
 - 6.4.1.1.3. Identification of responsible AU.
 - 6.4.1.2. Radiation shielding, as appropriate.
 - 6.4.1.3. Protection against fire, explosion, or flooding.
 - 6.4.1.4. Protection against accidental breakage of primary storage containers.
 - 6.4.1.5. Protection against unauthorized access or removal.
- 6.5. Transport of Radioactive Material (RAM)
 - 6.5.1. Refer to RSC Policy 98-4.
 - 6.5.2. Hand-transport of RAM outside designated RAM use area.
 - 6.5.2.1. Transport in containers that reasonably secure the RAM from accidents such as spills and that are labeled as to the radioactive contents. "Reasonably secure" means using a strong, tight container or, if liquid, secondary containment appropriate to prevent leakage if the primary container leaks. (This policy does not apply to very small quantities of RAM, such as counting vials, microscope slides, autoradiography film systems or sealed sources.)
 - 6.5.3. Hand-transport of RAM outside the confines of a building.
 - 6.5.3.1. Transport in packaging equivalent to that required by the Department of Transportation (DOT) for the shipment of RAM.
 - 6.5.3.1.1. Transport in original packaging and labeling the RAM had when it was received from the vendor.
 - 6.5.3.1.2. Transport small quantities of RAM (i.e., millicurie quantities) in strong, tight

AU MANUAL

containers. If liquid form, secondary containment is required.

- 6.5.3.1.3. The package or container must be labeled on the outside with the radionuclide, activity, and a contact person and phone number to call in case the individual transporting the RAM has an accident.
 - 6.5.3.2. Adhere to safe pedestrian traffic rules including, but not limited to the following.
 - 6.5.3.2.1. Cross streets only at marked crosswalks.
 - 6.5.3.2.2. Cross only with the traffic light, if applicable.
 - 6.5.3.2.3. Cross only after looking both ways.
 - 6.5.3.3. Individuals transporting RAM by a non-motorized vehicle (e.g., cart, dolly) outside the confines of a building must follow the same rules as the hand- transporter above.
 - 6.5.4. Transport of RAM by motorized vehicle must be in accordance with DOT regulations. Do not transport RAM in a motorized vehicle without specific written approval of the RSO.
 - 6.5.4.1. RAM must be transported in approved containers and labeled in accordance with DOT regulations.
 - 6.5.4.2. Individuals who operate motorized vehicles transporting RAM must be trained in accordance with DOT regulations.
 - 6.5.5. All incidents involving RAM in transport outside the confines of an area specifically approved for RAM use shall immediately be reported to the RSO. If there is any indication of a RAM spill or damage to the package that could result in a spill, the transporter shall take steps to secure potentially contaminated areas until RSO personnel arrive.
- 6.6. Inventory of Radioactive Material (RAM)
- 6.6.1. Unsealed
 - 6.6.1.1. Ensure adequate inventory records of unsealed RAM are maintained. Inventories of unsealed sources must be submitted using the RSO-provided computer printout during the first 15 days of each calendar quarter (calendar quarters begin on the first days of January, April, July, and October).
 - 6.6.1.2. Failure to submit inventory records will result in a non-compliance being issued and could result in the loss of privileges to order or use RAM. If no unsealed RAM is in possession, the AU must still submit an initial zero unsealed RAM inventory, but is not required to submit subsequent periodic zero unsealed RAM inventories.
 - 6.6.1.3. The RSO will mail a copy of the printout to each AU by the first day of each calendar quarter. If the computer printout is not received in time for submission on the 15th, it is the responsibility of the AU to contact the RSO for a duplicate copy.
 - 6.6.1.4. The inventory record required of each AU must contain the date of receipt, radionuclide, activity, chemical and/or physical form, activity received, and data associated with the disposal of the material.
 - 6.6.1.5. A proper inventory shall be conducted by checking the actual quantities of RAM in the laboratory against the listing on the RSO-provided computer printout. All discrepancies must be noted and the printout signed and dated by the AU, a backup AU, or an AU designated individual.

AU MANUAL

6.6.1.6. The AU shall maintain a copy of the most recent RSO of provided computer printout in their laboratory or in a location readily accessible to laboratory personnel.

6.6.1.6.1. EXCEPTION(S):RAM with half-lives less than ten (10) days used under a human-use authorization is exempted from the computerized inventory record requirement.

6.6.2. Sealed

6.6.2.1. Ensure adequate inventory records of sealed RAM are maintained. Inventories of sealed sources must be submitted using the RSO of-provided computer printout during the first 15 days of the second month of each calendar quarter (second month of calendar quarters February, May, August, and November).

6.6.2.2. Failure to submit inventory records will result in a non-compliance, and if applicable associated points, being issued and could result in the loss of privileges to order or use RAM.

6.6.2.3. The RSO of will mail a copy of the printout to each AU with one or more sealed source by the first day of the second month of each calendar quarter. If the computer printout is not received in time for submission on the 15th day of the second month of the calendar quarter, it is the responsibility of the AU to contact the RSO of for a duplicate copy.

6.6.2.4. A proper inventory shall be conducted by confirming the actual location of the sealed source against the listing on the RSO of-provided computer printout. All discrepancies, along with use/non-use during the last calendar quarter must be noted. The printout must be signed and dated by the AU, a backup AU or an AU designated individual.

6.7. Special Requirements for Sealed Sources

6.7.1. Sealed sources are used for teaching and research, as well as for routine diagnostic and therapeutic human-use procedures. AUs of sealed sources shall ensure the following:

6.7.1.1. Sealed sources are made readily available to RSO of representatives for routine leak testing.

6.7.1.2. Sealed sources are stored and used in a manner in keeping with the ALARA philosophy.

6.7.1.3. All sealed sources under the AU's authorization are attended or, when not in use and unattended, secured from unauthorized access or removal.

6.7.1.4. All sealed sources are accounted for on the AU's inventories.

7. OPERATION AND MAINTENANCE OF A RAM-USE LABORATORY

7.1. Commissioning an Area of Use

7.1.1. An AU may request additional area(s) of use (e.g., laboratory) to be commissioned by submitting an RS Form 6, 30, or 31, as appropriate. Complete all applicable sections including applicant's signature and Department or Division Chair's signature.

7.1.2. Refer to Section 4.2 for more detail on addition rooms to a RAM authorization.

7.2. Decommissioning an Area of Use

7.2.1. Notify the RSO of at least 30 days in advance, of intent to decommission an area of use. (Note: If the RSO of is not notified at least 30 days in advance the AU may not be released from responsibility within the time period expected by the AU.)

AU MANUAL

- 7.2.2. To maintain a RAM authorization, the authorization must include an area for storage of RAM, an area for use (e.g., experimentation) of RAM and an area for counting RAM. The uses may be in one or more area of use (e.g., laboratory).
- 7.2.3. Refer to Section 4.3 for more detail on decommissioning a room from a RAM authorization.
- 7.3. Posting of RAM Laboratories
- 7.3.1. All RAM areas of use are considered restricted for the purpose of radiation exposure control.
- 7.3.2. Untrained individuals should be escorted by the AU or a RAM RW.
- 7.3.3. Posting or removal of "Caution Radioactive Material" signs on areas of use doors and doorways shall be performed only by a representative of the RSO. Posting or removal of posting from areas within areas of use (e.g., on hood, refrigerators, or cabinets) is the AU's responsibility.
- 7.3.3.1. Laboratories or areas, refrigerators, freezers, hoods, and containers in which RAM is used or stored shall be conspicuously posted with a sign exhibiting the trefoil symbol and the words:

CAUTION - RADIOACTIVE MATERIAL

- 7.3.3.2. Each radiation area (an accessible area where an individual could receive a dose exceeding 0.05 mSv (5 mrem) in any one hour at 30 cm from a source or from a surface the radiation is penetrating) shall be conspicuously posted with a sign exhibiting the trefoil symbol and the words:

CAUTION - RADIATION AREA

- 7.3.3.3. Each high radiation area (an accessible area where an individual could receive a dose exceeding 1 mSv (100 mrem) in one hour at 30 cm from a source or from a surface the radiation is penetrating) shall be conspicuously posted with a sign exhibiting the trefoil symbol and the words:

CAUTION - HIGH RADIATION AREA

- 7.3.3.4. Each very high radiation area (an accessible area where an individual could receive an absorbed dose exceeding 5 grays (500 rads) in one hour at one meter from a source or from a surface the radiation is penetrating) shall be conspicuously posted with a sign exhibiting the trefoil symbol and the words:

GRAVE DANGER - VERY HIGH RADIATION AREA

- 7.3.3.4.1. Very high radiation areas require additional security controls. Consult the RSO and OAC 3701:1-38 for the most current requirement.
- 7.3.4. The OHIO DEPARTMENT OF HEALTH NOTICE TO EMPLOYEES shall be posted in the laboratory in a clearly visible area. Unless approval is granted by the ODH, this posting must be green. (Copies are available through the RSO.)
- 7.3.5. Every vial, bottle, flask, pail or tube which contains RAM shall be identified with the trefoil symbol and the words "Caution Radioactive Materials".
- 7.3.5.1. NOTE: Groups of tubes, vials, etc., are not individually required to be labeled if they are stored in a larger properly labeled holder.

AU MANUAL

- 7.3.6. RAM in storage greater than 8 hours or left unattended must be labeled with the following information. The labeling requirements include, but are not limited to stock RAM, radioactive waste, and dilution solutions.
 - 7.3.6.1. The trefoil symbol.
 - 7.3.6.2. "Caution Radioactive Material".
 - 7.3.6.3. The responsible AU's name or AU number.
 - 7.3.6.4. The radionuclide, activity, and date of activity calculation.
- 7.3.7. A temporary waste container that has less than 0.1 mCi and will be used for less than one day may be marked in the following manner:
 - 7.3.7.1. Trefoil and "Caution Radioactive Material" sign.
 - 7.3.7.2. AU's name or AU number, and the radionuclide.
 - 7.3.7.3. The date listed as "today" and activity listed as "<0.1 mCi".
- 7.3.8. Radiation emergency procedures shall be posted in each area of use (e.g., laboratory) in a clearly visible area. For standard research laboratories, RS Form 34, "EMERGENCY PROCEDURES INCIDENTS INVOLVING RADIOACTIVE MATERIAL" or an equivalent posting may be used.
- 7.4. Notification of Non-compliances and/or Areas of Concern.
 - 7.4.1. Communication and discussion of non-compliances and areas of concern are an important part of RAM-use laboratory operations.
 - 7.4.2. The most recent semi-annual period's non-compliance report(s) and/or area-of- concern notice(s) should be posted for personnel to reference or it must be clearly documented all RAM RWs have been informed about the report results with emphasis on any non-compliances noted and corrective action implemented.
- 7.5. Maxims of Good Radiation Laboratory Practice
 - 7.5.1. The prevention of an internal exposure caused by the entry of RAM into the body, and the minimization of external exposure requires the development and use of appropriate laboratory techniques. Good housekeeping, personal habits, and the proper use of equipment are essential ingredients. Typical guides for AUs or RWs using RAM follow:
 - 7.5.1.1. There must be a mechanism to control access and secure RAM from unauthorized removal or access when an AU or a RW is not able to keep the RAM under constant surveillance. This can be accomplished by locking the laboratory door and/or locking the RAM storage/use area(s) within the laboratory.
 - 7.5.1.2. Non-essential persons shall not be allowed in the immediate RAM work area while RAM procedures are in progress.
 - 7.5.1.3. If possible, a portion of the laboratory shall be set aside to be used only for procedures involving RAM.
 - 7.5.1.3.1. RAM work areas should be kept as small as practical.
 - 7.5.1.3.2. RAM should be handled and used only in the designated RAM work area.
 - 7.5.1.3.3. Non-essential materials (i.e., materials not directly involved in the ongoing

AU MANUAL

experiment) should not be brought into the RAM work area.

- 7.5.1.4. RAM procedures should be planned ahead. A practice run without RAM should be performed in advance to test and gain experience of the procedure.
- 7.5.1.5. A contamination survey is recommended prior to working with RAM to ensure contamination does not exist from a previous procedure.
- 7.5.1.6. Experiments involving RAM in gaseous, vaporous and/or volatile form(s) and dusts shall be performed in an area under negative air pressure, and in a fume hood or glove box that exhausts to the outside atmosphere. All transfers and dilutions should be performed in functioning fume hoods or glove boxes whenever appropriate.
- 7.5.1.7. Exercise deliberate care when handling RAM. Establish procedures to minimize splashes, splatters, spills, and the production of aerosols whenever RAM liquids are being used in experimental procedures.
- 7.5.1.8. Never carry contaminated items (e.g., paper towels) or unsealed RAM outside the designated (e.g., papered) RAM work area unless it is in a strong, tight container or precautions are taken to prevent contamination from falling onto the floor or other horizontal surfaces. Suggested precautions are to carry the RAM in a plastic container, a plastic bag, or on a tray.
- 7.5.1.9. Shielding should be used when applicable to ensure all personnel radiation exposures are kept ALARA. (Lead shielding for gamma rays, plastic shielding for higher energy beta particles.)
- 7.5.1.10. Absorbent paper shall cover workbenches, trays and other work surfaces where RAM is handled and/or used.
 - 7.5.1.10.1. Absorbent paper used in RAM work areas should be routinely monitored and disposed of as necessary to keep a clean and contamination free work area.
 - 7.5.1.10.2. The designated RAM work area (e.g., absorbent paper or work tray) should be clearly marked with radiation warning tape delineating where the potentially RAM contaminated area is located.
- 7.5.1.11. Lab coats, protective gloves, and, if required for the radionuclide used, personal dosimeters shall be worn, as a minimum, when handling RAM. The use of eye protection is strongly recommended.
- 7.5.1.12. Pipetting by mouth is prohibited anywhere within a laboratory approved for RAM use. Automatic pipetters, rubber bulbs, syringes, or other mechanical devices shall be used in RAM use areas.
- 7.5.1.13. Hair should be fashioned to prevent it from falling into the RAM work area.
- 7.5.1.14. Do not place portable survey meters in the RAM work areas or store in RAM storage containers. (The survey meter could become contaminated and rendered useless.)
- 7.5.1.15. RAM in liquid form should be stored in secure containers. Transportation of liquid RAM should be performed in double containers.
- 7.5.1.16. RAM that is sealed in a double container on which the outside has been verified free of loose contamination may be handled without PPE. Examples of this would be packages received in shipment or waste pails which have been surveyed and are ready for transport to the RSO.

AU MANUAL

- 7.5.1.17. Food and drink storage is prohibited in laboratories approved for RAM use. Refrigerators shall not be used for the storage of food or drink in laboratories approved for RAM use.
 - 7.5.1.18. Eating, drinking, chewing gum, using tobacco products, the preparation of food or drink, and the application of cosmetics are prohibited in laboratories approved for RAM use.
 - 7.5.1.19. Laboratories approved for RAM use should be kept clean and orderly.
 - 7.5.1.20. After a RAM-use procedure is completed, and before leaving the RAM-use area/laboratory, personnel should wash their hands and when possible from a radionuclide standpoint, monitor themselves.
 - 7.5.1.21. Decontamination and spill containment supplies should be maintained in an easily accessible location.
 - 7.5.1.22. All safety items and/or equipment should be checked periodically to ensure they are providing the safety feature intended.
 - 7.5.1.23. Any equipment from a RAM-use laboratory that may have come in contact with RAM (e.g., used with RAM) must be surveyed by RSO of personnel prior to its release from the laboratory for maintenance, repair, disposal, or transfer.
 - 7.5.1.24. Hazard communication markings, such as, radioactive tape, labels and signs, must be properly used. Marking non-radioactive items as radioactive is inappropriate and could lead to confusion and/or an escalated incident.
- 7.6. Radiation Laboratory Monitoring
- 7.6.1. Use of Survey Meters
 - 7.6.1.1. When performing experiments using unsealed RAM, except very low energy beta emitters such as tritium, a calibrated survey meter shall be readily available that is appropriate for the type and activity of radionuclide being used.
 - 7.6.1.2. The RAM work area and laboratory personnel involved in the RAM usage shall be monitored for RAM contamination (using appropriate survey meter) following each use of RAM.
 - 7.6.1.3. Prior to starting an experimental procedure for which a survey meter is required to be available and before using a survey meter, perform a preoperational check consisting of the following:
 - 7.6.1.3.1. Check that cables are connected properly, and no evidence of physical damage exists.
 - 7.6.1.3.2. Ensure the battery condition is satisfactory. If not, replace and recheck.
 - 7.6.1.3.3. Check the calibration label to ensure the survey meter calibration has not expired. Calibration is good for one year. An out-of-calibration survey meter should not be used until it is recalibrated. (If an emergency situation exists and an out-of-calibration survey meter is the only one available, it can be used temporarily until Radiation Safety personnel arrive with a calibrated survey meter.)
 - 7.6.1.3.4. It is recommended that survey meters are checked for detection of RAM with a known radiation source to ensure the meter is responding.
 - 7.6.1.4. Care should be taken to avoid contaminating the survey meter and/or probe.
 - 7.6.1.4.1. Contamination control of probes should never include covering with plastic, parafilm

AU MANUAL

or other material, as this significantly decreases the efficiency of the probe/survey meter to detect RAM.

- 7.6.1.5. For contamination surveys, hold the probe of the survey meter approximately 1 cm from the surface and move the probe laterally, at a rate of 2 to 5 cm per second.
- 7.6.1.6. Keep the audio response "on" for immediate indication of increasing levels of contamination. Because a time delay of up to 20 seconds exists for some survey meter responses, when increasing counts are heard, stop and wait for the survey meter to indicate a constant value.
- 7.6.1.7. Reminder: A survey meter only indicates the presence of RAM; it does not indicate whether the RAM is removable.

7.6.2. Surveying Unsealed Source Use Areas for Removable Contamination (“wipe test”)

Table 1 - Action Levels for Removable Surface Contamination

	Type of Radioactive Material (RAM)					
	Alpha Emitters		Beta, Gamma, X-ray Emitters		Low-Risk Beta and X-ray Emitters	
Type of Surface	$\mu\text{Ci}/\text{cm}^2$	dpm/ 100 cm^2	$\mu\text{Ci}/\text{cm}^2$	dpm/ 100 cm^2	$\mu\text{Ci}/\text{cm}^2$	dpm/ 100 cm^2
1. Unrestrictive Areas	9^{-8}	20	9^{-7}	200	9^{-6}	2,000
2. Restrictive Areas	9^{-7}	200	9^{-6}	2,000	9^{-5}	20,000
3. Personal clothing worn only in restrictive areas	9^{-8}	20	9^{-7}	200	9^{-6}	2,000
4. Protective clothing worn only in restricted areas	9^{-7}	200	9^{-6}	2,000	9^{-5}	20,000
5. Skin	9^{-7}	200	9^{-7}	200	9^{-6}	2,000

NOTE #1: Averaging is acceptable over areas of up to 300 cm^2 or for floors, walls, and ceiling, 100 cm^2 . Averaging is also acceptable over 100 cm^2 for skin or, for the hands, over the whole area of the hand, nominally 300 cm^2 .

NOTE #2: Beta- or x-ray emitter values are applicable for all beta- or x-ray emitters other than those considered low risk. Low-risk nuclides include C-14, H-3, S-35, Tc-99m, and others whose beta energies are less than 0.2 MeV maximum whose gamma- or x-ray emission is less than 0.1R/hr at 1 meter per curie, and whose permissible concentration in air (see ODH rule 3701:1-38) is greater than 10^6 $\mu\text{Ci}/\text{ml}$ Records and Reports of Surveys.

- 7.6.2.1. Perform the “wipe test”, at selected locations around the laboratory. Wipe an area of approximately 100 cm^2 . Apply light pressure to the wipe paper.
- 7.6.2.2. When performing the “wipe test”, areas that should not have any RAM contamination, but are routinely handled (e.g., drawer handles, faucets) or which are frequently used (e.g., general laboratory area, desks, computer workstations) should be swiped.
- 7.6.2.3. At a minimum a “wipe test” should include swipes on door knobs, light switches, floors at entrances to the laboratory, refrigerator and freezer door handles, general use areas ("cold areas"), as well as in RAM use and storage areas such as work benches, fume hoods and RAM storage containers.

AU MANUAL

- 7.6.2.4. Inner surfaces of sinks and drains should also be “wipe tested” to ensure unauthorized sink disposal is not occurring.
- 7.6.2.5. A “wipe test” survey should begin by swiping areas where contamination is least suspected to be present and by progressing toward areas most likely to be contaminated.
- 7.6.2.6. Removable contamination levels that exceed the values listed in Table 1 shall be cleaned promptly with soap and water, or a commercial decontaminating solution. After decontamination, these areas should be “wipe tested” again and the results reviewed to ascertain if decontamination has been effective. If contamination levels remain in excess of the referenced values, contact the RSO. (Note: UC's ALARA policy recommends decontamination of areas exhibiting greater than 100 CPM above background.)
- 7.6.2.7. Any contamination detected on a floor, or any contamination greater than 1000 cpm/100 cm² on any surface outside a marked RAM work area must be reported immediately to the AU and the RSO.

7.6.3. Routine Surveys

- 7.6.3.1. All areas where unsealed RAM is used shall have the area and equipment therein surveyed for contamination at least monthly.
 - 7.6.3.1.1. This survey shall be documented.
 - 7.6.3.1.2. This survey shall include a meter survey appropriate for the activity and radionuclides used, if applicable, and wipe tests.
- 7.6.3.2. RAM use areas where greater than 0.2 mCi (200 µCi) of unsealed RAM is used at any one time shall be surveyed for removable contamination during the week of use or as required by the RSO.
 - 7.6.3.2.1. This survey shall be documented.
 - 7.6.3.2.2. This survey shall include a meter survey appropriate for the activity and radionuclides used, if applicable, and wipe tests.
 - 7.6.3.2.3. It is recommended that a survey be performed as soon as practical after the procedure is completed.
- 7.6.3.3. Prior to performing the "wipe test", the laboratory should be monitored with a survey meter. The survey meter will help locate RAM and areas that potentially have removable contamination.
- 7.6.3.4. All survey results shall be documented on RS Form 12, “AUTHORIZED USER ROUTINE LABORATORY SURVEY REPORT”, or its equivalent. Documentation must at a minimum include the following.
 - 7.6.3.4.1. Area of use surveyed (i.e., building and laboratory number).
 - 7.6.3.4.2. Date of survey.
 - 7.6.3.4.3. Surveyor's name.
 - 7.6.3.4.4. Description of instrument used for analysis (make, model, serial #, efficiency for detection of all radionuclides).
 - 7.6.3.4.5. Locations surveyed.
 - 7.6.3.4.6. Results and any follow-up actions (decontamination efforts).

AU MANUAL

- 7.6.3.4.6.1. Contamination detected must be recorded in disintegrations per minute (DPM) or microcuries, or have the counts per minute (CPM) recorded with the efficiency of the instrument used to monitor the contamination. (DPM = CPM/EFFICIENCY)
- 7.6.3.5. If no use occurs during a month, "no use" may be documented in lieu of a survey.
 - 7.6.3.5.1. Storage is a "use". "No use" means no RAM in possession.
 - 7.6.3.5.2. Minimum documentation for "no use" is date of last clean survey, date of last use, and date of documentation of "no use". Records must reflect a clean survey after date of last use.
- 7.6.3.6. Survey records should be maintained in a radiation record book or file. These records must be maintained for at least three (3) years, and must be available for RSO of review.
- 7.7. Laboratory Emergency Procedures
 - 7.7.1. Refer to Section **15: LABORATORY EMERGENCY PROCEDURES** of this manual for a detailed listing of actions to take for various emergencies.

8. RSO of INSPECTIONS, SURVEYS, AUDITS AND NON-COMPLIANCE ASSESSMENT

8.1. Non-human Use Authorization Inspections

- 8.1.1. At least quarterly or more frequently at the discretion of the RSO, RSO of representatives will conduct a survey of all areas authorized for use of unsealed RAM. The results will be recorded, documented, and maintained in the RSO of.
 - 8.1.1.1. Each approved RAM area of use shall be surveyed for contamination with a survey meter which is appropriate for the activity and radionuclide(s) being used. The survey shall include all work areas (e.g., RAM designated and non-RAM areas).
 - 8.1.1.2. Wipe test surveys of unsealed RAM use areas will be performed.
 - 8.1.1.3. The AU will be informed if wipe test results indicate contamination greater than 100 cpm/100 cm². If survey results show contamination exceeding the quantities specified in Table 1, any contamination is detected on the floor, or greater than 1000 cpm/100 cm² is detected on any surface outside a marked RAM work area, the AU will be informed immediately. Different responses (as requested on the report) will be required for different levels of contamination found during the survey.
 - 8.1.1.4. If non-compliances in posting, use or storage of RAM, eating, drinking or smoking, safety precautions, or other radiation safety policy are noted during a laboratory survey, a notice of non-compliance will be sent to the AU.
 - 8.1.1.4.1. If available, the AU/AU staff will be notified of the non-compliance at the time of observation.
 - 8.1.1.4.2. Where applicable points will be assessed according to the non-compliance point system outlined in **APPENDIX V: POINT SYSTEM** and Section 8.3 of this manual.
- 8.1.2. Annually, or more frequently at the discretion of the RSO, a representative of the RSO of shall perform an AU authorization audit for the purpose of evaluating overall regulatory compliance.
 - 8.1.2.1. The AU or designee (a specific authorization-referenced RAM RW) may be present for

AU MANUAL

this audit.

- 8.1.2.2. An authorization's compliance to the RCSP will be evaluated using the point system outlined in **APPENDIX V: POINT SYSTEM** and Section **8.3** of this manual.

8.2. Human-use Authorization Inspections

- 8.2.1. Each quarter or more frequently at the discretion of the RSO, a representative of the RSO will conduct an audit for the purpose of determining overall regulatory compliance and specific compliance with ODH rules. These audits are performed at the department and/or division level.
- 8.2.2. Each month or more frequently at the discretion of the RSO, general areas of use surveys (meter survey and wipe tests) shall be performed by a representative of the RSO in areas when unsealed RAM is approved for use.
- 8.2.3. Human-use authorizations are not evaluated using the point system; however, the departments and/or divisions are evaluated based on the percent of record-keeping inaccuracies (i.e., errors/omissions) noted during audits and are assessed as follows.

Table 2 - Audit Assessment Criteria

<u>% ERRORS/OMMISSIONS</u>	<u>CLASSIFICATION</u>
Less than 0.1%	Excellent
0.1% – 0.5%	Very Good
0.5% - 1.0%	Good
1.0% - 1.5% (or only 1 error/omission)	Satisfactory
1.5% - 2.0%	Needs Improvement
Greater than 2.0%	Unsatisfactory

- 8.2.4. Repetitive non-compliances or any other concerns may also be presented to the RSC by the RSO. The RSC will take whatever actions are deemed necessary.

8.3. Non-human Use Compliance Assessment (Point System)

- 8.3.1. All non-compliances noted will be documented and addressed to the responsible AU(s) for comment and corrective action.
- 8.3.2. A point system shall be used to evaluate each non-human use authorization's performance regarding radiation safety practices and procedures. The current point system is listed in **APPENDIX V: POINT SYSTEM**.
- 8.3.3. Points accumulate for a specified six (6) month semi-annual period (i.e., first semiannual period is January through June and second semiannual period is July through December).
- 8.3.4. Non-compliance and assessment of points are not limited to observations made during an audit or survey. Non-compliances and assessment of points may also be assessed because of failure to comply with inventory and personnel dosimetry requirements; safety problems noted during waste pickups; and any other observed non-compliance.
- 8.3.5. If total points assessed during a semi-annual audit period are less than 25 the following action is taken.
 - 8.3.5.1. Notice(s) of non-compliance is sent to the AU by the RSO.

AU MANUAL

- 8.3.5.2. The notice(s) of non-compliance shall be posted in the main laboratory or it must be documented that all RAM RW who work under the authorization have been informed of the non-compliance.
- 8.3.6. If the total points assessed during a semi-annual audit period are ≥ 25 , but ≤ 75 , the following action is taken.
 - 8.3.6.1. Notice(s) of non-compliance is sent to the AU by the RSO of.
 - 8.3.6.2. The period's non-compliance record is presented to the RSC or an Executive Committee of the RSC. At the discretion of the RSO or any member of the RSC, a recommendation may be made to the RSC to suspend for cause the RAM-use privileges of any AU.
 - 8.3.6.3. The RSC shall send an advisory notice.
 - 8.3.6.4. The notice(s) of non-compliance and the advisory notice shall be posted in the main laboratory or it must be documented that all RAM RW who work under the authorization have been informed of the notice(s).
- 8.3.7. If two sequential semi-annual audit periods result in 25 points or more being accumulated during each period, or one audit period is greater than 75 points, the following apply.
 - 8.3.7.1. Notice(s) of non-compliance is sent to the AU by the RSO of.
 - 8.3.7.2. The applicable periods' non-compliance record is presented to the RSC or an Executive Committee of the RSC. The RSC (or the Executive Committee) will consider suspension of AU privileges for a period of one month.
 - 8.3.7.3. The RSC shall send a notice of reprimand.
 - 8.3.7.4. The notice(s) of non-compliance and the reprimand and, if applicable, suspension notice shall be posted in the main laboratory or it must be documented that all RAM RW who work under the authorization have been informed of the notices.
- 8.3.8. If any three semi-annual audit periods over a two (2) year period are assigned 25 or more points, or one audit period is greater than 100 points, the following apply.
 - 8.3.8.1. Notice(s) of non-compliance is sent to the AU by the RSO of.
 - 8.3.8.2. A meeting of an Executive Committee of the RSC will be called to consider suspension of AU privileges for up to three (3) months.
 - 8.3.8.3. If suspended, reapplication for AU status may be required, and may include retraining and formal presentation of the application by the prospective AU at the next full RSC meeting.
 - 8.3.8.4. The notice(s) of non-compliance and, if applicable, any reprimand or suspension notice shall be posted in the main laboratory or it must be documented that all RAM RWs who work under the authorization have been informed of the notices.
- 8.3.9. If all four of the semi-annual audit periods over a two (2) year period are assigned 25 or more points, the following apply.
 - 8.3.9.1. Notice(s) of non-compliance is sent to the AU by the RSO of.
 - 8.3.9.2. A meeting of an Executive Committee of the RSC will be called to consider a suspension of AU privileges for up to six (6) months.
 - 8.3.9.3. If suspended, reapplication for AU status will be required, and will include retraining and formal presentation of the application by the prospective AU at the next full RSC meeting.

AU MANUAL

- 8.3.9.4. The notice(s) of non-compliance and, if applicable, any reprimand or suspension notice shall be posted in the main laboratory or it must be documented that all RAM RWs who work under the authorization have been informed of the notices.
- 8.3.10. Appeals concerning the results of an audit may be made to the Executive Committee of the RSC if the sum total of points assessed during the semi-annual audit period is 25 or more. Appeals for point removal when the sum total is less than 25 points will not be reviewed by the RSC. The AU shall forward such appeals to the RSO.
- 8.4. Special Rules for Retraining
 - 8.4.1. Refer to RSC Policy 20-1 for more information.
 - 8.4.2. If any AU is not retrained annually, the AU will have RAM ordering privileges suspended until the required retraining is accomplished.
 - 8.4.2.1. If an AU still has not met their annual retraining obligation by the first RSC meeting after missing their annual obligation, the RSC shall terminate the AU's RAM RW and authorization status. Reapplication of the RAM RW status and/or authorization shall require the AU to complete the initial site-specific training.
 - 8.4.3. Any RAM RW who does not attend retraining annually, will be suspended from working with RAM until the retraining requirement is accomplished.
 - 8.4.3.1. If a RAM RW has not met their annual retraining obligation by the first RSC meeting following suspension of an individual's RAM RW status, the RSC shall terminate the individual's RAM RW status. Reapplication of the RAM RW status shall require the individual to complete the initial site-specific training.
 - 8.4.4. If a suspended RAM RW is found working with (using) RAM, the AU(s) listed on the worker's RS Form 2.0 as AU/Supervisor will:
 - 8.4.4.1. If a non-human use AU, the AU's authorization(s) shall receive an automatic 75 points which requires the RSC to consider suspension of the authorization(s).
 - 8.4.4.2. If a human-use AU, the AU shall be required to meet with the RSC, either executive or full committee, and provide explanation and corrective action.
- 8.5. Applying RCSP Rules to Visitors and Ancillary Staff
 - 8.5.1. See RSC Policy 03-1 for more information.
 - 8.5.2. The AU and the AU's staff are expected to be vigilant about compliance within areas of use listed on the AU's authorization. This vigilance includes, but is not limited to, questioning individuals who enter the laboratory and are not part of the routine laboratory staff, and ensuring the individuals need to be in the laboratory and are aware of major RCSP rules. Rules that should be emphasized are no food and/or drink in the laboratory and do not handle anything with the "caution radioactive material" symbol.
 - 8.5.3. If the member of the AU's staff observes a non-compliance in an area of use, the AU's staff member is expected to immediately correct the non-compliance. If the non-compliant individual can be identified, the observing staff member shall discuss the noncompliance with the individual and follow-up by:
 - 8.5.3.1. If the non-compliant individual is a member of the AU's staff, the AU shall be notified in a timely manner. The AU shall take more long-term corrective action, including, but not limited to appropriate disciplinary action.

AU MANUAL

- 8.5.3.2. If the non-compliant individual is a member of another AU's staff, the observing individual shall notify their AU, and either the observing individual or their AU shall notify the non-compliant individual's supervisor (i.e., other AU).
- 8.5.3.2.1. The non-compliant individual's supervisor (i.e., other AU) shall take more long-term corrective action including, but not limited to, appropriate disciplinary action and shall provide written feedback about the action taken.
- 8.5.3.2.2. The AU shall contact the RSO for assistance if it appears the supervisor (i.e., other AU) will not take appropriate action to improve the compliance of their staff. The RSO (or ARSO for the RSO) shall contact the supervisor (i.e., other AU) and/or the supervisor's superior to discuss the problem. The RSO (or ARSO for the RSO) shall provide written feedback to the AU/AU staff member about action taken.
- 8.5.3.3. If the non-compliant individual is a member of ancillary staff the observing individual shall notify their AU, and either the observing individual or their AU shall notify the individual's supervisor.
- 8.5.3.3.1. The individual's supervisor is expected to take appropriate disciplinary action as noted in "recommended disciplinary action" under (2) below and shall provide written feedback about the action taken.
- 8.5.3.3.2. The AU/AU staff shall contact the RSO for assistance if it appears the supervisor will not take appropriate action to improve the compliance of their staff. The RSO (or ARSO for the RSO) shall contact the supervisor and/or the supervisor's superior to discuss the problem. The RSO (or ARSO for the RSO) shall provide written feedback to the AU/AU staff member about the action taken.
- 8.5.3.3.3. In the event the non-compliant individual indicates they will not come into compliance the AU and the individual's supervisor should be notified immediately.
- 8.5.4. If the non-compliant individual cannot be identified, the observing individual shall take action to correct the noncompliance and inform their AU of the noncompliance observed. The identifying individual and/or the AU shall inform all other AUs who use the laboratory and supervisors of ancillary workers present in the area or suspected of causing the noncompliance of the noncompliance. (Note: an AU/AU staff member may contact the RSO to obtain a list of other AUs.)

9. PERSONNEL PROTECTION

9.1. Time, Distance and Shielding

- 9.1.1. Persons working with RAM can reduce their external exposure by controlling the factors of time, distance and shielding. The AU and/or RW is urged to consider the interdependency of these factors in determining the best combination thereof to achieve ALARA.
- 9.1.2. The exposure from a photon (and beta within their range) source varies directly with the time of exposure varies inversely with the distance (is square of the distance if a point source) from a source, and decreases exponentially with the absorption of radiation by shielding material.
- 9.1.3. Application of the time-distance relationship for ALARA application may be illustrated by considering that the execution of an operation involving a photon emitter at twice the normal distance is just as effective in reducing the exposure as completing the operation in one-

AU MANUAL

fourth of the time. However, in many instances, the additional distance makes the operation more cumbersome, with a consequent increase in the time required to complete the task.

9.2. Internal Contamination Prevention

- 9.2.1. To prevent the entry of RAM into the body, RAM should not be permitted to contaminate the skin or hair. The use of gloves, lab coats, eye protection, and hand washing can assist in preventing skin contamination.
- 9.2.2. To prevent entry of RAM into the body through ingestion, no eating, drinking or smoking should be performed in a RAM use area. In addition, food, drink and tobacco products should not be stored in RAM use areas.
- 9.2.3. To prevent entry of RAM into the body through the skin, no application of cosmetics should be performed in a RAM use area.
- 9.2.4. Radioactive vapors or gases shall not be released into the laboratory. The use of fume hoods and chemical traps during procedures which may result in volatile RAM must be used to assist in preventing inhalation of RAM. Iodinations must be performed in hoods approved by the RSO and specifically designed to trap iodine gas and to monitor releases (e.g., the Iodination Facility at the RSO).
- 9.2.5. RAM should not be allowed to enter the body through inhalation or ingestion, through an open wound or by absorption through the skin.

9.3. The Declared Pregnant Worker

- 9.3.1. Refer to RSC Policy 13-1.
- 9.3.2. The radiation dose received by most RAM radiation workers under the RCSP is minimal and continuing to work with RAM is not a concern if the individual follows good radiation safety practices.
- 9.3.3. RAM radiation workers have the option to declare their pregnancy. Individuals are not considered declared pregnant workers until they declare the pregnancy in writing to the RSO.
- 9.3.4. The declaration must include the following information. The RSC approved form "Declaration of Pregnancy" (RS Form 33) is available on the Radiation Safety website (<https://research.uc.edu/support/offices/radsafety/overview>) and may be used to declare a pregnancy.
 - 9.3.4.1. The name of the individual
 - 9.3.4.2. The date of declaration
 - 9.3.4.3. The type of radiation exposed to in the workplace (and)
 - 9.3.4.4. The estimated date of conception
- 9.3.5. The radiation dose limit to the embryo/fetus of a declared pregnant worker is 500 millirem total dose equivalent over the term of the pregnancy.
- 9.3.6. Declared pregnant workers may request a meeting with the RSO. During the meeting the RSO will review the following, along with answering any questions the individual may have.
 - 9.3.6.1. The individual's exposure record. If the record indicates an exposure to the embryo/fetus greater than 500 millirem may occur, the RSO will initiate steps to move the individual to a position of lower radiation exposure and one that the exposure can be maintained

AU MANUAL

less than 500 millirem.

- 9.3.6.2. Procedures to minimize exposure to the embryo/fetus.
- 9.3.7. Whether a pregnancy is declared or not, pregnant workers are expected to apply good radiation safety practices and keep their dose and the dose to their embryo/fetus ALARA. For RAM radiation workers this means.
 - 9.3.7.1. The individual may continue to work with and around radioactive material, unless deemed otherwise by the RSO.
 - 9.3.7.2. The individual should use appropriate shielding for the radionuclide and activity used.
 - 9.3.7.3. The individual should wear appropriate personnel protective equipment this includes but is not limited to gloves and lab coat.
 - 9.3.7.4. The individual should not eat, drink, smoke or apply cosmetics in an area approved for RAM. This includes not storing food or drink in an area where RAM is used, whether it is later consumed in an area where RAM is approved for use or not.
- 9.3.8. Pregnant workers or individuals who are considering becoming pregnant should review NRC regulatory guide 8.13. This guide covers the effects of radiation to the embryo and fetus and is available on the NRC website (www.nrc.gov) or from the RSO.

10. PERSONNEL MONITORING

10.1. Dosimetry Requirements

- 10.1.1. ODH rules require all persons who work with RAM (e.g., faculty, staff, students) to register for and wear a radiation dosimeter when the possibility of receiving an external dose exceeding 10 percent of regulatory limits exists.
- 10.1.2. UC's license commits to all persons using RAM which emits betas with maximum energies greater than 250 keV, or gamma or x-rays of any energy be monitored. Exemptions from the requirement may be approved by the RSC on a case-by-case basis.
- 10.1.3. For procedures or experiments in which there is a potential of receiving a significant dose to the hand, finger dosimeters (ring badges) are required. The general RCSP policy is to require a finger dosimeter for all persons who handle RAM and who are required to be monitored according to Section **10.1** of this manual.
- 10.1.4. When deemed appropriate by the RSO, wrist dosimeters will be required.
- 10.1.5. Visitors to RAM use areas may also be required to wear a dosimeter if the possibility exists they may exceed a regulatory limit. For additional information and procedural details regarding visitors, contact the RSO.
- 10.1.6. For any female RW who declares a pregnancy, the RSO will determine if there is a necessity for additional dosimeters and will furnish same.
- 10.1.7. For experiments and procedures involving the use of neutron sources, dosimeters sensitive to neutron radiation must be worn.

10.2. Dosimetry Exemptions

- 10.2.1. AUs and/or RWs using exclusively radionuclides emitting only alpha or beta particles with maximum energies less than 250 keV are exempt from the requirement of wearing personnel dosimeters.

AU MANUAL

10.2.2. In the exempted cases above, bioassays may be required for purposes of personnel monitoring. (See Section **10.6** of this manual)

10.3. Care and Use of Dosimeters

10.3.1. Personnel dosimeters are for use by a single RW and shall not be shared, reassigned or discarded.

10.3.2. Personnel dosimeters issued by UC are limited for use to monitor radiation exposure from radiation sources covered by the RCSP.

10.3.3. Personnel dosimetry does not provide protection from radiation; it only provides an "after-the-fact" assessment of the amount of radiation to which it (and presumably the wearer) was exposed.

10.3.4. Dosimeters should be worn at a position appropriate for the work being performed. This means at the level where the highest exposure would be expected. For example, at whole body dosimeters should be waist-level if standing in front of the RAM-use bench or ring dosimeter should be worn on the hand used to pick up the container of RAM.

10.3.5. At the discretion of the RSO, persons who wear lead aprons to reduce radiation exposure to the trunk of the body may be required to wear two dosimeters, one outside the lead apron at the collar and a second dosimeter under the lead apron at approximately waist level.

10.3.6. Radiation dosimeters can be very sensitive to environmental conditions such as heat, moisture and light. Dosimeters should be used properly and should not be taken home or stored in cars.

10.3.7. Radiation dosimeters should be stored in low background areas (e.g., offices, non- RAM rooms) when not being worn by RWs.

10.3.8. Radiation dosimeters are NOT to be worn during personal medical or dental procedures. **THEY ARE STRICTLY FOR OCCUPATIONAL USE.**

10.4. Dosimetry Analysis and Reports

10.4.1. Personnel dosimetry must be returned to the RSO for analysis in accordance with the following schedule.

10.4.1.1. All dosimeters are to be exchanged either quarterly or monthly, unless otherwise specified in writing by the RSO or RSC.

10.4.2. Dosimetry Exchange Procedures

10.4.2.1. Before dosimeters are returned, new dosimeters must be picked up so unmonitored exposures are prevented and an accurate exposure history for all RWs can be maintained. The dosimeter exchange deadlines are as follows:

10.4.2.1.1. Monthly dosimeters must be picked up by the third working day of the month. Quarterly dosimeters must be picked up by the third 3 working day of the quarter.

10.4.2.1.2. Monthly dosimeters from the previous month must be returned by the 10th day of the month after use. Quarterly dosimeters from the previous quarter must be returned by the 10th day of the quarter after use.

10.4.2.1.3. Any late return dosimeters (i.e., after the 10th) will require completion of a dosimetry follow-up form sent by the RSO.

10.4.3. Lost, Late Return, or Damaged Personnel Dosimeters

AU MANUAL

- 10.4.3.1. Lost or damaged dosimeters must be reported immediately to the RSO.
- 10.4.3.2. Temporary replacement dosimeters will be issued if such dosimeters are lost/damaged prior to their routine monthly exchange.
- 10.4.3.3. The RSO will review the loss or damage with the involved individual in order that a realistic estimate of the individual's expected exposure can be assigned for that monitoring period.
 - 10.4.3.3.1. This review is generally performed on a dosimetry follow-up form that must be returned to the RSO within 21 days of issue.

10.5. ALARA Investigations

- 10.5.1. The RSO or designee will review all dosimetry reports at least once each calendar quarter.
- 10.5.2. UC has established "Investigational Levels" for occupational external radiation exposure which, when exceeded, will initiate a review or investigation by the RSC and/or RSO. The Investigational Levels adopted are listed in Table 2. These levels apply to the exposure of individual workers.

Table 3 - ALARA Investigational Levels

AREA/Dose	LEVEL I (10%) *	LEVEL II (30%) *
Effective Dose	125 mrem	375 mrem
Any organ, other than eye	1250 mrem	3750 mrem
Eye	375 mrem	1125 mrem
Skin	1250 mrem	3750 mrem
Extremity	1250 mrem	3750 mrem

* Investigational Levels are in millirem (mrem) per calendar quarter.

- 10.5.3. The following actions will be taken at the Investigational Levels, as outlined in **Table 3-ALARA INVESTIGATIONAL LEVELS**.
 - 10.5.3.1. Quarterly exposure of individuals to less than Investigational Level I will have no further action taken unless deemed appropriate by the RSO.
 - 10.5.3.2. Quarterly exposures equal to or exceeding Investigational Level I, but less than Investigational Level II.
 - 10.5.3.2.1. The RSO or RSO delegate will review the exposures and report the results at the first RSC meeting following the quarter when the exposure was reported and evaluations completed.
 - 10.5.3.2.2. If the exposure does not equal or exceed Investigational Level II, no action related specifically to the exposure is required unless deemed appropriate by the RSC.
 - 10.5.3.3. Quarterly exposures equal to or exceeding Investigational Level II.
 - 10.5.3.3.1. The RSO or RSO delegate will investigate in a timely manner the cause(s) of such exposures and, if warranted, take action.
 - 10.5.3.3.2. A report of the investigations, actions taken, if any, and copies of the individual's exposure records or the equivalent (e.g., quarterly dose and summary of investigation results) will be presented to the RSC at the first meeting following completion of the

AU MANUAL

investigations.

10.5.3.4. Establishment of an individual occupational worker's Investigational Level II above that listed in Table 2.

10.5.3.4.1. In cases where a RAM RW's or group of RAM RWs' exposures need to exceed Investigational Level II, a different, higher Investigational Level II may be established by the RSC on the basis that it is consistent with good ALARA practices for that individual or group.

10.5.3.4.2. Justification for an increase in the Investigational Level II will be documented.

10.6. Bioassay

10.6.1. As a general principle, bioassays will be required after any incident in which there exists the possibility of internalization of radionuclides. Bioassays may be required at any time at the discretion of the RSO or at the direction of the RSC.

10.6.2. Baseline bioassays may be required prior to initiating a procedure.

10.6.3. Bioassays include such tests as thyroid uptake and the radioanalysis of urine, fecal samples, or sputum.

10.6.4. Tritium Bioassays

10.6.4.1. Urine bioassays (i.e., radioanalysis of urine sample) are required for individuals using tritium (H-3), in accordance with the following schedule.

10.6.4.2. If the amount of tritium used at any one time is less than 100 mCi, a bioassay will be performed only if requested.

10.6.4.3. In the event that a RAM RW is certain, or suspects, that tritium has been ingested, inhaled or absorbed, a urine specimen shall be submitted for radioanalysis.

10.6.4.4. If the amount of tritium used at any time is greater than 100 mCi, but less than 10 curies, bioassays shall be performed prior to use, at the time of use, and weekly thereafter, until the results of radioanalysis are at or below normal levels.

10.6.4.5. If the amount of tritium used at any one time is 10 curies or greater, bioassays shall be performed daily until the results of radioanalysis are at or below normal levels.

10.6.4.6. Any detectable amount of tritium above the minimum detectable activity will be called to the attention of the individual involved, and to the AU. In this event, the RSO or RSO delegate will conduct an investigation and determine appropriate action.

10.6.4.7. Users of tritium sources in metallic foils are exempt from the above bioassay requirements.

10.6.5. Iodine Bioassays

10.6.5.1. Thyroid uptake analysis is required for individuals using radioiodine in accordance with the following schedule.

10.6.5.2. RAM RW preparing I-131 dosages and/or administering I-131 dosages to patients or human research subjects in quantities exceeding 30 mCi shall have a thyroid bioassay performed within three calendar days of the procedure.

10.6.5.2.1. NOTE: Individuals present but not physically handling an encapsulated I-131 dosage above 30 mCi during an oral administration would not be required to have a thyroid

AU MANUAL

bioassay unless the capsule was dropped, damaged, rejected by the patient or if any contaminations were identified after administration. Should a bioassay for the individual(s) who physically administered the dose yield an indication of an uptake, anyone who was present during the administration would then also be required to undergo a thyroid bioassay.

- 10.6.5.3. RAM RW opening containers in excess of 2 mCi of I-125 and/or I-131 will require a thyroid bioassay. The thyroid bioassay should be performed between 6-72 hours after the iodine usage and must be performed no earlier than 6 hours after and within three working days.
- 10.6.5.4. RAM RW whose work involves the research use of radioiodine in forms and quantities cited in Table 3, "Activity Levels Above Which Bioassays For I-125 or I-131 Are Necessary" are required to have routine thyroid uptake bioassays made at quarterly intervals.
- 10.6.5.5. The RSO of will notify all AUs who have purchased in excess of 2 mCi of I-125 or I-131 during the preceding calendar quarter that thyroid uptake bioassays may be required.

Table 4 - Activity Levels Above Which Bioassays for I-125 or I-131 are Necessary

Type of Operation	Activity Handled in Unsealed Form Making Bioassay Necessary*	
	Volatile or Dispersible*	Bound to Nonvolatile Agent*
Processes carried out in open room or bench, with possible escape of iodine from process vessels.	1 mCi	10 mCi
Processes with possible escape of iodine carried out within a fume hood of adequate design, face velocity, and performance reliability (see Section 9.2.4).	10 mCi	100 mCi
Processes carried out within glove boxes, ordinarily closed, but with possible release of iodine from process and occasional exposure to contaminated box and box leakage.	100 mCi	1000 mCi

*Quantities may be considered the cumulative amount handled by a worker during a 3-month period (e.g., the total quantity introduced into a chemical or physical process over a 3-month period) or on one or more occasions in that period, by opening stock reagent containers from which radioactive iodine may escape. Quantities in the right-hand column may be used when it can be shown that activity being used is always chemically bound and processed in such a manner that I-125 or I-131 will remain in nonvolatile form and diluted to concentrations less than 0.1 mCi/mg of nonvolatile agent. However, certain compounds where radioiodine is normally bound are known to release radioiodine when the material is processed, and the left-hand column may then be applicable. In those laboratories working only with I-125 in radioimmunoassay (RIA) kits, the quantities of I-125 are very small and in less volatile forms; thus, bioassay requirements may be judged from the right-hand column. In field operations, where reagent containers are opened outdoors for simple operations such as pouring liquid solutions, the above table does not apply; bioassay should be performed whenever an individual employee handles in open form (e.g., an open bottle or container) more than 50 μ Ci i at any one time. Operations involving the routine use of I-125 or I-131 in an open room or bench should be discouraged. Whenever practicable, sealed bottles or containers holding more than 0.1 mCi of I-125 or I-131 should be opened at least initially within hoods having adequate face velocities of 0.5 m/sec (100 feet/min.) or more. (Ref. Table 1, NRC Regulatory Guide 8.20.)

11. PERSONAL PROTECTIVE EQUIPMENT (PPE)

11.1. PPE is worn to help prevent skin contamination, to minimize routes of entry into the body, and

AU MANUAL

to help protect sensitive organs, such as the eyes.

11.2. AUs and RWs are required to wear PPE when using RAM. PPE may include lab coats or coveralls, rubber/plastic gloves, shoe covers, safety glasses, and in emergency work, disposable uniforms and respirators.

11.3. The minimum PPE when working with RAM is a lab coat and gloves. The minimum PPE of a lab coat and gloves is based on the assumption a RAM RW is wearing shoes that cover the feet, and pants (or equivalent leg protection) that covers the skin of the legs. Open-toed shoes, shorts, or dresses that do not cover the bare skin may not provide adequate protection and it is strongly recommended that personnel wearing open-toed shoes, shorts, and dresses use additional PPE, such as, shoe covers and/or coveralls, scrubs, or pants. Appropriate eye protection is also strongly recommended.

11.3.1. Lab coat

11.3.1.1. When worn as PPE, the lab coat shall be worn with the following precautions.

11.3.1.2. Be sure RAM lab coat is buttoned when worn.

11.3.1.3. Be sure the RAM lab coat's sleeves are to the wrist.

11.3.1.4. Do not wear RAM lab coats out of the RAM use area, unless traveling between RAM use areas as part of ongoing RAM work.

11.3.1.5. UNDER NO CIRCUMSTANCES ARE RAM LAB COATS TO BE WORN TO THE CAFETERIA, OR WHILE EATING!

11.3.1.6. Store RAM lab coats away from personal clothing.

11.3.1.7. Contaminated RAM lab coats must be decontaminated or disposed of as radioactive waste, if the contamination measurably exceeds background levels.

11.3.1.8. RAM lab coats must be monitored prior to their release from RAM use areas (e.g., for laundering).

11.3.2. Gloves

11.3.2.1. When worn as PPE, gloves shall be worn with the following precautions.

11.3.2.2. Check when first donned and occasionally during the procedure for cracks and/or tears.

11.3.2.3. Monitor gloves or change gloves when the possibility of being contaminated exists.

11.3.2.4. Wear a double set of gloves when working with millicurie levels of activity (i.e., ≥ 1 mCi) or when performing a spill cleanup.

11.3.2.5. Change gloves prior to handling items on surfaces outside the RAM work area or whenever levels of radioactivity significantly change.

11.3.2.6. Dispose of RAM use gloves as RAM waste.

11.3.3. Eye Protection

11.3.3.1. When using radionuclides which decay by beta emission and the emission is greater than 250 keV, eye protection is required.

11.3.3.2. If there is a potential for RAM to be splashed or aerosols to be produced, eye protection is required.

AU MANUAL

11.3.3.3. Eye protection includes, safety glasses, goggles and/or face shields. Eye protection may include area shields if the shielding is between the RAM and the eyes.

11.3.4. Respiratory Protection

11.3.4.1. Respiratory protection equipment is generally not required and should only be worn by properly qualified individuals who are trained, physically qualified, and fit tested for the specific equipment.

11.3.4.2. Contact the institution's Environmental Health and Safety Office, or Safety Department regarding requirements for training, physicals and fit testing requirements.

11.3.4.3. Any procedures or situations that may require respiratory equipment should be brought to the attention of the RSO as soon as they are identified.

12. DECONTAMINATION PROCEDURES

12.1. This section is intended to provide some basic information on decontamination techniques for personnel and property. Material Safety Data Sheets (MSDS) should be referenced and/or the RSO may be contacted for further guidance and assistance.

12.1.1. Personnel Decontamination

12.1.1.1. Personnel should be decontaminated as quickly as possible using the least drastic methods necessary. Decontamination efforts should begin with mild methods. Mild method should be continued as long as they are effective. Progressing to harsher methods should only occur as necessary.

12.1.1.2. In all decontamination procedures, every effort should be made to prevent the spread of contamination. Personnel performing the decontamination should take all necessary precautions to protect themselves.

12.1.1.3. The progress of decontamination should be closely monitored by surveying between successive washings or techniques.

12.1.1.4. The use of log sheets indicating decontamination techniques used and survey results should be maintained to keep track of the progress of the decontamination.

12.1.1.5. Define the area(s) of contamination using appropriate monitoring techniques.

12.1.1.6. Begin decontamination of skin by rinsing with cool or lukewarm water. If this is unsuccessful, wash gently with mild soap. Cool or lukewarm water should be used because hot water causes the skin pores to open, driving contamination deeper into the skin, and cold water closes the pores, trapping contamination in the skin.

12.1.1.7. In all efforts to decontaminate skin, care must be exercised to prevent skin damage. Chapping or cracking of the skin from repeated washing or abrasion can lead to the absorption of radioactivity through minor cuts.

12.1.1.8. The use of a hand cream or lotion between washings may help prevent chapping and skin damage.

12.1.1.9. If extensive washing is required or harsher methods must be used, obtain assistance from medical personnel before proceeding.

12.1.1.10. Chemical complexing or oxidizing agents should be used only under medical supervision.

12.1.1.11. After removal of skin or personnel contamination, individuals should, as soon as

AU MANUAL

practicable take a thorough shower with special attention to washing hair, hands, and fingernails.

12.1.1.12. A table summarizing personnel decontamination techniques in increasing order of harshness is found in **APPENDIX VI: PERSONNEL DECONTAMINATION METHODS**.

12.1.2. Equipment and Materials Decontamination

- 12.1.2.1. Equipment and materials may need to be decontaminated for a number of reasons, including reducing the potential for exposure of personnel to radiation, allowing for release of material or equipment for unrestricted use, salvaging valuable material, or reducing the volume of contaminated solid waste.
- 12.1.2.2. Decontamination should be performed as soon as possible after contamination occurs or is detected. This is especially important for liquid contaminants, which can penetrate further into materials as contact time increases.
- 12.1.2.3. Equipment or materials that cannot be easily or cost effectively decontaminated should be evaluated for possible limited use in RAM use areas or disposed as radioactive waste.
- 12.1.2.4. A simple decontamination procedure is to use decontamination solution or mild detergent.
- 12.1.2.5. When decontaminating with toweling, wipe once and then discard towel as radioactive waste (disposable paper towels are useful). Scrubbing tends to spread and/or redistribute contamination.
- 12.1.2.6. Soaking may be effective, but do not place unprotected hands in decontamination solution used to soak a contaminated item. Remove item using tongs or other remote handling tool.
- 12.1.2.7. Many harsher decontamination methods have been developed, most of which are physical or chemical processes involving cleaning, abrasive, chemical and electrochemical methods.
 - 12.1.2.7.1. Cleaning methods are nondestructive and include manual (wiping, mopping, and vacuuming) and mechanical (soaking, spraying, vibrating) techniques.
 - 12.1.2.7.2. Abrasive methods are destructive and involve the progressive removal of the contaminated material.
 - 12.1.2.7.3. Chemical methods include both nondestructive techniques (using detergents and complexing agents which remove contamination by emulsifying and ion exchange), and destructive techniques (using caustics or oxidizing agents).
- 12.1.2.8. Other method(s) of lowering contamination levels on equipment or materials involves aging and/or sealing. Contact the RSO before using either of these method(s).
 - 12.1.2.8.1. Aging involves isolating a contaminated object until radioactive decay has reduced the contamination to an acceptable level. This approach is suitable only for short-lived radionuclides. Aging for ten (10) half-lives reduces the contamination level to one-thousandth of the original level.
 - 12.1.2.8.2. Sealing involves fixing radioactivity in place by covering it with an impermeable material. Sealing is most effective for alpha and low-level beta- gamma contamination. Most sealants are adequate for shielding alpha and some beta

AU MANUAL

contamination, but thick, high-density materials are needed to sufficiently attenuate gamma rays. Sealing is of most value where the primary concern is preventing the spread of relatively low levels of contamination, and where dose rate is not a serious concern. It is important to be aware that if sealing is used, the equipment must be appropriately labeled and may ultimately need to be disposed as radioactive waste.

- 12.1.2.9. Selection of decontamination methods depends on the material or equipment being decontaminated. If more than one method is to be used, the least harsh or abrasive method should be used first. The RSO of can be contacted for further assistance in planning a decontamination procedure.
- 12.1.2.10. All materials used to decontaminate, or which may contain any portion of the contamination must be disposed of as radioactive waste (e.g., absorbent material, gloves, shoe covers, liquids).
- 12.1.2.11. A summary of decontamination methods can be found in **APPENDIX VII: EQUIPMENT/PROPERTY DECONTAMINATION METHODS**.

13. WASTE HANDLING AND DISPOSAL

ALL RAM MUST BE DISPOSED OF THROUGH THE RSO of

13.1. General Information

- 13.1.1. Radioactive waste is any RAM or items that contain or are contaminated with RAM that is no longer useful. (See the definition of “radioactive waste” in **APPENDIX II: GLOSSARY OF TERMS**.)
- 13.1.2. Prior to initiating new procedures and/or processes using RAM, AUs should:
 - 13.1.2.1. Determine a method of disposal exists for waste materials that will be generated and contact the RSO of for assistance if a new waste stream may be generated, especially one that also contains carcinogens, biohazards, or hazardous chemicals.
 - 13.1.2.2. Ensure funding is available to pay for any special disposal method that is not covered by routine waste disposal recharge fees. Radiation waste that is not covered by routine fees include, but is not limited to, sealed sources and waste not segregated in accordance with RCSP requirements.
- 13.1.3. Accurate records of the materials making up the radioactive waste must be maintained.
- 13.1.4. Radioactive waste containers must be secured from unauthorized access and removal. Ensure radioactive waste is under the direct observation of a RAM RW or is locked up.
- 13.1.5. Radioactive waste containers shall be stored as close to the work area as feasible. Keeping waste containers close to the work areas minimizes the possibility of spillage during the transfer of waste to the container. When possible, smaller bench top accumulation containers should also be used. After completion of an experiment, waste should be transferred from the bench top accumulation container to the RSO of supplied primary RAM waste container.
- 13.1.6. Radioactive waste containers shall be closed unless waste material is being added or access is required for sampling.
- 13.1.7. Liquid waste containers shall be stored on absorbent material or be placed in a secondary container (e.g., a tray to collect any spillage that may occur).
- 13.1.8. Appropriate PPE and dosimetry shall be worn when handling radioactive waste. Proper PPE

AU MANUAL

includes, as a minimum, a lab coat and gloves.

- 13.1.9. All radioactive wastes containing carcinogens, biohazards, or hazardous chemicals shall be clearly identified in accordance with safety and regulatory requirements for the particular hazard. **Contact the RSO of for assistance before generating a radioactive waste that also contains another hazardous component.**
 - 13.1.10. All RAM shall be disposed through the RSO of. Decay-in-storage in the laboratory is prohibited unless specifically approved in writing by the RSO and/or the RSC. (Approval will be specifically listed in an AU's authorization.)
 - 13.1.11. All radioactive waste shall be separated by half-life classification and physical/chemical form.
 - 13.1.11.1. Minimize the number of radionuclides per waste container.
 - 13.1.12. Only use radioactive waste containers for the disposal of radioactive waste or other material potentially contaminated with RAM. Do not dispose of non-RAM in radioactive waste containers.
 - 13.1.13. Do not place radioactive waste, RAM, or other material potentially contaminated with RAM into regular trash receptacles.
 - 13.1.14. Do not dispose of radioactive waste into the sewer system.
- 13.2. Requesting a Waste Pickup and/or Supplies
- 13.2.1. A waste pickup request may be made by calling the RSO of during normal working hours, or by logging on to the Radiation Safety website (<https://research.uc.edu/support/offices/radsafety/overview>).
 - 13.2.1.1. Survey the exterior of carboys and other waste containers. Decontaminate, if necessary, before requesting a waste pickup.
 - 13.2.1.2. Waste containers shall be ready for pickup when the request is made. RSO of personnel may make the pickup as soon as one hour after the request is made depending on the schedule and/or location of RSO of personnel.
 - 13.2.1.3. The RSO of goal is to respond to all waste pick up requests by the end of the second workday after a request is received.
 - 13.2.2. When making a waste pickup request, basic information about the location of the waste, and the amount and types of waste containers must be provided.
 - 13.2.2.1. A request for replacement containers and/or additional supplies may be included on a waste pickup request. These items will be delivered by RSO of personnel at the time of the waste pickup.
 - 13.2.2.2. Laboratory personnel may also pickup needed supplies at the Package Receipt window in the RSO of East Campus Office at any time during normal working hours.
- 13.3. Radioactive Waste Separation
- 13.3.1. There are four half-life ($T_{1/2}$) classifications.
 - 13.3.1.1. Separate waste by half-life classification.
 - 13.3.1.2. Contact the RSO of if a waste will be generated that mixes half-life classifications in the same waste container.

AU MANUAL

- 13.3.1.3. Approval to mix half-life classifications is given in writing by the RSO and/or RSC. Approval is specifically listed in an AU's authorization.

Table 5 - Half-Life Classifications

	<u>Half-life Classifications</u>
L1	Radionuclides with $T_{1/2} \leq 15$ days (e.g., ^{32}P)
L2	Radionuclides with $T_{1/2} > 15$ days, but ≤ 65 days (e.g., ^{86}Rb , ^{51}Cr and ^{125}I)
L3	Specified radionuclides with $T_{1/2} > 65$ days, but ≤ 120 days (e. g., ^{35}S , and ^{192}Ir)
L4	Radionuclides with $T_{1/2} > 120$ days (e.g., ^3H , ^{14}C , ^{22}Na , and ^{45}Ca)

- 13.3.2. There are seven physical/chemical form classifications.

13.3.2.1. Separate waste by physical/chemical form.

13.3.2.2. Minimize mixtures containing more than one physical/chemical form classification. Some mixtures may have no legal form of disposal.

13.3.2.3. Contact the RSO for classification/disposal instructions if a waste stream does not specifically fit into a defined physical/chemical form classification.

13.3.2.4. Approval to physical/chemical form classifications is given in writing by the RSO and/or RSC. Approval is specifically listed in an AU's authorization.

Table 6 - Physical/Chemical Form Classifications

	<u>Physical/Chemical Form Classifications</u>
CS	Combustible dry solid waste paper, plastics and other burnable trash type wastes with no standing or pourable liquids.
NS	Noncombustible dry solid waste including metal, glass, and other non-burnable trash type wastes with no standing or pourable liquids.
SL	Non-hazardous liquids, bulk liquids in which the chemical component(s) is not hazardous as defined under Resource Conservation and Recovery Act (RCRA) criteria and meets local criteria for disposal into the sanitary sewer. The radioactive component of the waste must be readily soluble in water or be readily dispersible biological material.
HL	Mixed waste liquids, bulk liquids in which the chemical component(s) is hazardous as defined under RCRA criteria. (It is very important that HL remains separate from other waste types. Disposal of mixed waste is difficult and expensive. Contact the institutional safety department to determine if a chemical component(s) is hazardous as defined under RCRA criteria.)
SV	Liquid scintillation vials containing liquid counting media and sample materials that contain radioactivity.

AU MANUAL

	<u>Physical/Chemical Form Classifications</u>
PT	Pathological human and animal tissues, organs, body parts, body fluids, excreta, and animal bedding that are not classified as infectious waste.
IW	Infectious solid or liquid wastes as defined under OEPA regulations. (Contact the institutional biosafety office for guidance concerning the safe use and handling of infectious agents.) Includes, but is not limited to the following: cultures and stocks of infectious agents and associated biologicals; laboratory wastes that have or may have come into contact with infectious agents and present a substantial threat to public health; pathological wastes (in case of animals, only those exposed to zoonotic or infectious agent); waste materials from rooms of humans or animal enclosures where isolation was due to communicable diseases likely to transmit infectious agents; human and animal blood specimens and products (in case of animals, only those exposed to zoonotic or infectious agent); carcasses, body parts and bedding of animals exposed to zoonotic or infectious agents; sharp wastes used in treatment, diagnosis, or inoculation of human beings or animals or are likely to have come in contact with infectious agents in a laboratory (hypodermic needles, syringes, scalpel blades, broken glass articles).

13.4 Waste Packaging

13.4.1. Packaging instructions vary by physical/chemical form classification. Packaging instructions do not vary by half-life classification, but each half-life classification must be packaged in separate containers.

13.4.2 Solid (combustible (CS) and noncombustible (NS)) Waste

13.4.2.1. NOTE: Keep CS and NS waste streams separate even though these two physical/chemical form classifications are packaged using the same methodology.

13.4.2.2. Solid waste is dry solid waste that does not contain any of the following:

13.4.2.2.1. Freestanding liquids, wet absorbent materials or wet gels that may result in freestanding liquids.

13.4.2.2.2. Organic solvents.

13.4.2.2.3. Hazardous materials regulated by OEPA (e.g., arsenic, barium, cadmium, chromium, lead, mercury, selenium, or silver). (Contact the institution safety office to determine if a particular chemical is considered hazardous by OEPA regulations.)

13.4.2.2.4. Scintillation vials (empty or full and well plates)

13.4.2.2.5. Pathological or infectious materials.

13.4.2.2.6. Unprotected sharps such as blades or needles.

13.4.2.3. Place solid waste in a plastic pail lined with a plastic bag.

Figure 1 - Waste Pail

AU MANUAL



- 13.4.2.3.1. Pail and bag provided by the RSO.
 - 13.4.2.3.2. Never place waste directly into a plastic pail.
 - 13.4.2.3.3. Each pail is restricted from containing radionuclides from more than one half-life classification and one solid waste category, unless approved in writing on an AU's authorization by the RSO and/or RSC.
 - 13.4.2.4. Place sharp objects which have the potential to puncture or lacerate (e.g., pipettes, needles, scalpels, broken glass) into a rigid, puncture-resistant container prior to placement into the lined plastic pail.
 - 13.4.2.4.1. Clearly mark the container with the word "SHARPS".
 - 13.4.2.4.2. See **Section 13.4.11** of this manual for more information on sharps disposal.
 - 13.4.2.5. Prior to adding solid waste to a pail, partially complete the Waste Estimate Tag. Record the AU name, radionuclide and start fill date.
 - 13.4.2.6. Attach a RS Form 3, "RADIOACTIVE WASTE CONTAINER LOG SHEET" to the pail lid, or locate the RS Form 3 near the pail and note the location on the Waste Estimate Tag.
 - 13.4.2.6.1. Make an entry on the log sheet each time waste is added.
 - 13.4.2.6.2. Record the date, AU name, radionuclide, and estimated activity.
 - 13.4.2.7. Place solid waste into the bag until the pail is approximately 3/4 filled (about 3 inches from the top of the pail) or until the procedure(s) generating the waste stream ceases, whichever comes first. This is considered a "filled" pail.
 - 13.4.2.8. Securely close the bag using a twist seal, tie wrap, or tape when the pail is "filled".
 - 13.4.2.9. Complete the Waste Estimate Tag after sealing the bag. Record the fill date and estimated activity.
 - 13.4.2.10. Compile all Radioisotope Use Record cards relating to waste in the container and contact the RSO to pick up the pail.
 - 13.4.2.10.1. NOTE: Provide the original card if the pickup is the last for a particular stock vial. Provide a copy of the card if any RAM from the stock vial remains in the laboratory.
- 13.4.3 Non-hazardous Bulk Liquids (SL)
- 13.4.3.1. SL waste is liquid waste in which the chemical component(s) meets local criteria for disposal into the sanitary sewer.
 - 13.4.3.1.1. The radioactive component of the waste must be readily soluble in water or be readily dispersible biological material.
 - 13.4.3.1.2. The chemical component(s) may not be defined as hazardous under RCRA criteria. (Contact the institutional safety department to determine if a chemical component(s)

AU MANUAL

in the waste is considered hazardous.)

13.4.3.2. Place SL liquid waste in a carboy.

Figure 2 – Various Carboys



- 13.4.3.2.1. Carboy provided by the RSO, along with a plastic pail and bag for transport.
- 13.4.3.2.2. The standard carboy is a 2.5 gallon, wide-mouth carboy; however, smaller carboys are available upon request for low volume or concentrated liquid wastes.
- 13.4.3.2.3. Each carboy is restricted from containing radionuclides from more than one half-life classification and one bulk liquid category, unless approved in writing on an AU's authorization by the RSO and/or RSC.
- 13.4.3.3. Prior to adding any SL liquid waste to a carboy, partially complete the Waste Estimate Tag. Record the AU name, radionuclide, and start fill date.
- 13.4.3.4. Locate a RS Form 3, "RADIOACTIVE WASTE CONTAINER LOG SHEET" near the carboy. Note the RS Form 3 location on the Waste Estimate Tag.
 - 13.4.3.4.1. Make an entry on the log sheet each time waste is added.
 - 13.4.3.4.2. Record the date, AU name, radionuclide, and estimated activity.
- 13.4.3.5. Store a carboy while it is being filled on absorbent paper, and if possible, in a laboratory tray and/or hood.
 - 13.4.3.5.1. If a carboy is not in good condition or begins to leak, contact the RSO to have the waste transferred to a different carboy, or have it managed in another manner.
- 13.4.3.6. Check the pH of SL liquid waste periodically while filling the carboy.
 - 13.4.3.6.1. The pH of SL liquid waste must be between 6 and 8.
 - 13.4.3.6.2. If pH is outside the range of 6 and 8:
 - 13.4.3.6.2.1. Use buffers and adjust the pH regularly to minimize overflow when the carboy is full.
 - 13.4.3.6.2.2. Adjust the pH and allow it to stabilize for 24 hours.
 - 13.4.3.6.2.3. Agitate the carboy, recheck the pH, and adjust, if necessary, repeating this step after another 24 hours.
 - 13.4.3.6.2.4. Do not call for a waste pick up until the pH has stabilized between 6 and 8.
 - 13.4.3.6.3. The RSO staff will check the pH of the liquid waste before it is picked up and will not accept the waste if the pH is out of range.
- 13.4.3.7. Place liquid into the carboy until liquid begins to enter the carboy neck, or until the procedure(s) generating the waste stream ceases, whichever comes first. This is

AU MANUAL

considered a “filled” carboy. Always ensure a “filled” carboy has sufficient space in the neck for expansion.

13.4.3.8. Complete the Waste Estimate Tag once a carboy is "filled". Record the fill date and estimated activity.

13.4.3.9. Compile all Radioisotope Use Record cards relating to waste in the container and contact the RSO of to pick up the carboy.

13.4.3.9.1. NOTE: Provide the original card, if the pickup is the last for a particular stock vial. Provide a copy of the card if any RAM from the stock vial remains in the laboratory.

13.4.4. Mixed Waste (HL)

13.4.4.1. HL waste is a liquid waste in which a chemical component(s) is defined as hazardous under RCRA criteria.

13.4.4.1.1. NOTE: Disposal of Mixed Waste (HL) with a long half-life radioactive component may be very difficult and expensive. Consult the RSO of before generating any mixed waste.

13.4.4.2. Contact the institutional chemical safety office for assistance in determining the following:

13.4.4.2.1. If any chemical component in the waste to be generated is considered to be a hazardous or acutely hazardous chemical.

13.4.4.2.2. If there are concentration levels for the chemical component above which the waste is considered hazardous.

13.4.4.2.3. If chemical components that will be added to a container are compatible.

13.4.4.2.4. If the chemical components are compatible with the waste container and bag materials.

13.4.4.2.5. If any special safety precautions are required for handling and storing the hazardous chemical component of the waste.

13.4.4.3. The following subparagraphs are requirements that apply specifically to HL waste container management in a laboratory.

13.4.4.3.1. AUs shall request a waste pickup once an individual HL waste container is filled.

13.4.4.3.2. If a waste container is not in good condition or begins to leak, contact the RSO of to have the waste transferred to a good container, or have it managed in another manner that complies with hazardous waste management rules.

13.4.4.3.3. The container or its bag shall be compatible with the hazardous waste being stored so the ability of the container to contain the hazardous waste is not impaired.

13.4.4.3.4. The container shall be closed during storage, except when it is necessary to add or remove hazardous waste or sample the waste.

13.4.4.3.5. The container must be identified with the words “Hazardous waste” on the Waste Estimate Tag. Individually list the chemical components on the Waste Estimate Tag or the Waste Container Log Sheet.

13.4.4.3.6. An individual laboratory may not store more than ten (10) gallons of flammable liquid outside an approved flammable liquid storage cabinet.

AU MANUAL

13.4.4.4. Place HL liquid waste in a carboy.

13.4.4.4.1. Carboy provided by the RSO, along with a plastic pail and bag for transport.

13.4.4.4.2. The standard carboy is a 2.5 gallon, wide-mouth carboy; however, smaller carboys are available upon request for low volume or concentrated liquid wastes.

13.4.4.4.3. Each carboy is restricted from containing radionuclides from more than one half-life classification and one bulk liquid subcategory unless approved in writing on an AU's authorization by the RSO and/or RSC.

13.4.4.5. Store a carboy while it is being filled on absorbent paper, and if possible, in a laboratory tray and/or hood.

13.4.4.6. Prior to adding any HL liquid waste to a carboy, partially complete the Waste Estimate Tag.

13.4.4.6.1. Record the AU name, radionuclide, and start fill date.

13.4.4.6.2. Write "Hazardous Waste" and/or, if known, the chemical components that will be added to the container.

13.4.4.7. Locate a RS Form 3, "RADIOACTIVE WASTE CONTAINER LOG SHEET" near the carboy. Note the RS Form 3 location on the Waste Estimate Tag.

13.4.4.7.1. Make an entry on the log sheet each time waste is added.

13.4.4.7.2. Record the date, AU name, radionuclide, and estimated activity.

13.4.4.7.3. Record the complete chemical name, volume, and percentage by volume for mixtures (e.g., 100 ml of 50% methyl alcohol in water).

13.4.4.8. Place liquid into the carboy until liquid begins to enter the carboy neck, or until the procedure(s) generating the waste stream ceases, whichever comes first. This is considered a "filled" carboy. Always ensure a "filled" carboy has sufficient space in the neck for expansion.

13.4.4.9. Complete the Waste Estimate Tag once a carboy is "filled".

13.4.4.9.1. Record the fill date and estimated activity.

13.4.4.9.2. Record all hazardous chemicals in the container. Include the complete chemical name of each hazardous chemical and its percentage, by volume, in the waste.

13.4.4.10. Compile all the Radioisotope Use Record cards relating to waste in the container and contact the RSO to pick up the pail.

13.4.4.10.1. NOTE: Provide the original card if the pickup is the last for a particular vial. Provide a copy of the card if any RAM from the vial remains in the laboratory.

13.4.5. Liquid Scintillation Vials (SV)

13.4.5.1. SV waste is the liquid scintillation cocktail component and sample media contained in individual counting vials.

13.4.5.1.1. Dispose of scintillation vials that are not radioactive via the institution's non-RAM chemical waste disposal stream.

13.4.5.2. Place SV waste in a plastic pail lined with a plastic bag.

AU MANUAL

- 13.4.5.2.1. Pail and bag provided by the RSO.
- 13.4.5.2.2. Never place waste directly into a plastic pail.
- 13.4.5.2.3. Each pail is restricted from containing radionuclides from more than one half-life classification, unless approved in writing on an AU's authorization by the RSO and/or RSC.
- 13.4.5.3. Close scintillation vials securely before placing into the plastic bag.
- 13.4.5.4. Prior to adding any SV waste to a pail, partially complete a Waste Estimate Tag.
 - 13.4.5.4.1. Record the AU name, radionuclide, and start fill date.
 - 13.4.5.4.2. Write "Hazardous Waste" on the tag if the liquid scintillation cocktail is defined as hazardous under RCRA criteria. (Contact the institutional safety department to determine if a chemical component in the waste is considered a hazardous chemical.)
- 13.4.5.5. Attach a RS Form 3, "RADIOACTIVE WASTE CONTAINER LOG SHEET" to the pail lid or locate a RS Form 3 near the pail and note the location on the Waste Estimate Tag.
 - 13.4.5.5.1. Make an entry on the log sheet each time waste is added.
 - 13.4.5.5.2. Record the date, AU name, radionuclide, and estimated activity.
 - 13.4.5.5.3. Record the trade name of the liquid scintillation cocktail. Note the type of cocktail used (e.g., "Ultima Gold," "Aque-Solv").
- 13.4.5.6. Place SV waste into a plastic bag until it is approximately 3/4 full (about 3 inches from the top of the pail) or until the procedure(s) generating the waste stream ceases, whichever comes first. This is considered a "filled" pail.
- 13.4.5.7. Securely close the bag using a twist tie, tie wrap, or tape once a pail is "filled".
- 13.4.5.8. Complete the Waste Estimate Tag after sealing the bag.
 - 13.4.5.8.1. Record the estimated activity and fill date and attach to the bag.
 - 13.4.5.8.2. Record all trade name(s) of the liquid scintillation cocktails in the container (e.g., "Ultima Gold," "Aque-Solv").
 - 13.4.5.8.3. Ensure "Hazardous Waste" is written on the tag if any of the liquid scintillation cocktail in the pail is defined as hazardous under RCRA criteria.
- 13.4.5.9. Compile all the Radioisotope Use Record cards relating to waste in the container and contact the RSO to pick up the pail.
 - 13.4.5.9.1. NOTE: Provide the original card if the pickup is the last for a particular vial. Provide a copy of the card if any RAM from the vial remains in the laboratory.
- 13.4.6. Pathological Waste (PT) Solids
 - 13.4.6.1. PT solid waste is human and animal tissues, organs, body parts, solid excreta, and animal bedding that are not classified as infectious waste.
 - 13.4.6.2. Bedding must be kept separate and disposed in separate waste bags from animal tissue, organs, and body parts.
 - 13.4.6.3. Never place sharps into a PT waste bag. See Section **13.4.11** for information on

AU MANUAL

disposing sharps.

- 13.4.6.4. Double bag and freeze solid PT waste that is likely to become putrescent if it is not frozen or refrigerated (e.g., animal carcasses, body parts, large tissue samples, excreta).
- 13.4.6.5. Each bag is restricted from containing radionuclides from more than one half-life classification, unless approved in writing on an AU's authorization by the RSO and/or RSC.
- 13.4.6.6. Limit the activity in each solid PT waste bag to the following:

Table 7 - Solid PT Waste Bag Activity Limits

Radionuclides	Activity
^{210}Bi , ^{125}I , ^{129}I , ^{131}I , or ^{90}Sr	10 μCi
^3H , ^{14}C or ^{35}S	1 mCi
All other radionuclides	100 μCi

- 13.4.6.7. Prior to adding any PT waste to a bag, partially complete a Waste Estimate Tag.
 - 13.4.6.7.1. Record the AU name, radionuclide, and start fill date.
 - 13.4.6.7.2. Write "PT Waste" on the tag so it is clearly seen.
- 13.4.6.8. Securely close the bag using a twist tie, tie wrap, or tape when no more PT waste is expected to be added to the bag.
- 13.4.6.9. Complete the Waste Estimate Tag after sealing the bag.
 - 13.4.6.9.1. Record the estimated activity and fill date and attach to the bag.
 - 13.4.6.9.2. Ensure "PT Waste" is clearly written on the tag.
- 13.4.6.10. Compile all the Radioisotope Use Record cards relating to waste in the bag and contact the RSO of to pick up the waste.
 - 13.4.6.10.1. NOTE: Provide the original card if the pickup is the last for a particular vial. Provide a copy of the card if any RAM from the vial remains in the laboratory.
- 13.4.6.11. At the time of waste pickup, the RSO of shall place PT solid waste into a plastic pail lined with a plastic bag.
 - 13.4.6.11.1. Place animal bedding in a plastic bag separate from animal tissue, organs and body parts.
 - 13.4.6.11.2. If the PT waste is a large animal or other PT waste that cannot fit into a pail, the RSO of will use other appropriate containers or means to handle and transport the waste.
- 13.4.6.12. Additional packaging instructions for animal bedding PT waste.
 - 13.4.6.12.1. Place animal bedding into a pail with a plastic bag.
 - 13.4.6.12.1.1. Pail and bag provided by RSO of.
 - 13.4.6.12.1.2. The liquid content of the bedding should not cause freestanding liquid to form in the bag.
 - 13.4.6.12.2. Prior to adding animal bedding to a bag, attach a RS Form 3 "RADIOACTIVE

AU MANUAL

WASTE CONTAINER LOG SHEET” to the pail lid, or locate a RS Form 3 near the pail and note the location on the Waste Estimate Tag.

13.4.6.12.2.1. Make an entry on the log sheet each time waste is added.

13.4.6.12.2.2. Record the date, AU name, radionuclide, and estimated activity.

13.4.6.12.3. Place bedding into the bag until the pail is approximately 3/4 filled (about 3 inches from the top of the pail) or until the procedure(s) generating the waste stream ceases, whichever comes first. This is considered a “filled” pail.

13.4.6.12.3.1. Never place quantities greater than 4.5 gallons of animal bedding into one bag.

13.4.6.12.4. Securely close the bag using a twist seal, tie wrap, or tape when the pail is “filled”.

13.4.6.12.5. Complete the Waste Estimate Tag after sealing the bag.

13.4.6.12.5.1. Record the estimated activity and fill date and attach to the bag.

13.4.6.12.5.2. Ensure “PT Waste” is clearly written on the tag.

13.4.6.12.6. Compile all the Radioisotope Use Record Cards relating to waste in the container and contact the RSO to pick up the bag.

13.4.6.12.6.1. NOTE: Provide the original card if the pickup is the last for a particular vial.

Provide a copy of the card if any RAM from the vial remains in the laboratory.

13.4.7. Pathological Waste (PT) Liquid

13.4.7.1. PT liquid waste is human and animal body fluids and liquid excreta that are not classified as infectious waste.

13.4.7.2. Freeze or refrigerate PT liquid waste that is likely to become putrescent if it is not frozen or refrigerated.

13.4.7.3. Place the PT liquid waste into a plastic carboy.

13.4.7.3.1. Carboy provided by the RSO, along with a plastic pail and bag for transport.

13.4.7.3.2. The standard carboy is a 2.5 gallon, wide-mouth carboy; however, smaller carboys are available upon request for low volume liquid wastes or wastes that must be frozen or refrigerated. Use the smallest carboy sufficient to hold the waste.

13.4.7.3.3. The radioactive component of the waste must be readily soluble in water or be readily dispersible biological material.

13.4.7.3.4. Each carboy is restricted from containing radionuclides from more than one half-life classification unless approved in writing on an AU’s authorization by the RSO and/or RSC.

13.4.7.3.5. The liquid and its contents may not contain a hazardous waste as defined under RCRA. (Contact the institutional safety department to determine if a chemical component in the waste is considered hazardous.)

13.4.7.4. Prior to adding any PT liquid waste to a carboy, partially complete the Waste Estimate Tag.

13.4.7.4.1. Record the AU name, radionuclide, and start fill date.

13.4.7.4.2. Ensure “PT Waste” is clearly written on the tag.

AU MANUAL

- 13.4.7.5. Locate a waste summary log sheet near the carboy and note the log sheet location on the Waste Estimate Tag.
- 13.4.7.5.1. Make an entry on the log sheet each time waste is added.
 - 13.4.7.5.2. Record the date, AU name, radionuclide, and estimated activity.
- 13.4.7.6. Store a carboy while it is being filled on absorbent paper, and if possible, in a laboratory tray and/or hood.
- 13.4.7.6.1. If a carboy is not in good condition or begins to leak, contact the RSO of to have the waste transferred to a different carboy, or have it managed in another manner.
- 13.4.7.7. Check the pH of PT liquid waste periodically while filling the carboy.
- 13.4.7.7.1. The pH of PT liquid waste must be between 6 and 8.
 - 13.4.7.7.2. If the PT waste is outside the 6 to 8 pH range:
 - 13.4.7.7.2.1. Use buffers and adjust the pH regularly to minimize overflow when the carboy is full.
 - 13.4.7.7.2.2. Adjust the pH and allow it to stabilize for 24 hours.
 - 13.4.7.7.2.3. Agitate the carboy, recheck the pH, and adjust, if necessary, repeating this step after another 24 hours.
 - 13.4.7.7.2.4. Do not call for a waste pickup until the pH has stabilized between 6 and 8.
 - 13.4.7.7.3. The RSO of staff will check the pH of the liquid waste before it is picked up and will not accept the waste if the pH is out of range.
- 13.4.7.8. Place liquid into the carboy until liquid begins to enter the carboy neck, or until the procedure(s) generating the waste stream ceases, whichever comes first. This is considered a "filled" carboy. Always ensure a "filled" carboy has sufficient space in the neck for expansion. If the PT liquid waste is being frozen, ensure adequate space is always available for expansion of the frozen liquid to prevent a rupture of the carboy.
- 13.4.7.9. Complete the Waste Estimate Tag once a carboy is "filled".
- 13.4.7.9.1. Record the fill date and estimated activity.
 - 13.4.7.9.2. Ensure "PT Waste" is clearly written on the tag.
- 13.4.7.10. Compile all Radioisotope Use Record cards relating to waste in the container and contact the RSO of to pick up the carboy.
- 13.4.7.10.1. NOTE: Provide the original card if the pickup is the last for a particular stock vial. Provide a copy of the card if any RAM from the stock vial remains in the laboratory.
- 13.4.8 Infectious Waste (IW) Liquid
- 13.4.8.1 NOTE: DISPOSAL OF INFECTIOUS LONG HALF-LIFE RADIOACTIVE WASTE IS DIFFICULT AND EXPENSIVE, OR IMPOSSIBLE. CONSULT WITH THE RSO of BEFORE GENERATING ANY INFECTIOUS RADIOACTIVE WASTE.
 - 13.4.8.2 CAUTION: BIOHAZARD AND/OR INFECTIOUS WASTE SHALL BE RENDERED NON-INFECTIOUS OR SAFE FOR GENERAL HANDLING IN ACCORDANCE WITH PROCEDURES APPROVED BY THE IBC PRIOR TO DISPOSAL THROUGH

AU MANUAL

THE RSO of.

- 13.4.8.3 IW liquid waste is RAM waste also containing an infectious agent as defined under OEPA regulations and may be generated if zoonotic or infectious agents and their associated biologicals are used in association with RAM.
 - 13.4.8.3.1. Contact the institutional biosafety office for assistance in determining if the waste to be generated is infectious.
- 13.4.8.4 Freeze or refrigerate IW liquid waste that is likely to become putrescent if it is not frozen or refrigerated.
- 13.4.8.5 Place the IW liquid waste into a plastic carboy.
 - 13.4.8.5.1. Carboy provided by the RSO of, along with a plastic pail and bag for transport.
 - 13.4.8.5.2. The standard carboy is a 2.5 gallon, wide-mouth carboy; however, smaller carboys are available upon request for low volume liquid wastes or wastes that must be frozen or refrigerated. Use the smallest carboy sufficient to hold the waste.
 - 13.4.8.5.3. The radioactive component of the waste must be readily soluble in water or be readily dispersible biological material.
 - 13.4.8.5.4. Each carboy is restricted from containing radionuclides from more than one half-life classification unless approved in writing on an AU's authorization by the RSO and/or RSC.
 - 13.4.8.5.5. The liquid and its contents may not contain a hazardous waste as defined under RCRA. (Contact the institutional safety department to determine if a chemical component in the waste is considered hazardous.)
- 13.4.8.6 Prior to adding any IW liquid waste to a carboy, partially complete the Waste Estimate Tag.
 - 13.4.8.6.1. Record the AU name, radionuclide, and start fill date.
 - 13.4.8.6.2. Ensure "IW Waste" is clearly written on the tag.
 - 13.4.8.6.3. Clearly label liquid IW waste containers with the international biohazard symbol on two opposite sides of the container.
- 13.4.8.7 Locate a RS Form 3, "RADIOACTIVE WASTE CONTAINER LOG SHEET" near the carboy. Note the RS Form 3 location on the Waste Estimate Tag.
 - 13.4.8.7.1. Make an entry on the log sheet each time waste is added.
 - 13.4.8.7.2. Record the date, AU name, radionuclide, and estimated activity.
- 13.4.8.8 Store a carboy while it is being filled on absorbent paper, and if possible, in a laboratory tray and/or hood.
 - 13.4.8.8.1. If a carboy is not in good condition or begins to leak, contact the RSO of to have the waste transferred to a different carboy, or have it managed in another manner.
- 13.4.8.9 Check the pH of IW liquid waste periodically while filling the carboy.
 - 13.4.8.9.1. The pH of IW liquid waste must be between 6 and 8.
 - 13.4.8.9.2. If the IW liquid waste is outside the 6 to 8 pH range:

AU MANUAL

- 13.4.8.9.2.1. Use buffers and adjust the pH regularly to minimize overflow when the carboy is full.
- 13.4.8.9.2.2. Adjust the pH and allow it to stabilize for 24 hours.
- 13.4.8.9.2.3. Agitate the carboy, recheck the pH, and adjust, if necessary, repeating this step after another 24 hours.
- 13.4.8.9.2.4. Do not call for a waste pickup until the pH has stabilized between 6 and 8.
- 13.4.8.9.3. The RSO of staff will check the pH of the liquid waste before it is picked up and will not accept the waste if the pH is out of range.
- 13.4.8.10 Render the waste non-infectious or safe for general handling in accordance with IBC procedures before preparing for RSO of pickup.
 - 13.4.8.10.1. If rendered legally non-infectious, remove or deface the biohazard markings on the carboy in accordance with IBC instructions.
- 13.4.8.11 Place liquid into the carboy until liquid begins to enter the carboy neck, or until the procedure(s) generating the waste stream ceases, whichever comes first. This is considered a "filled" carboy. Always ensure a "filled" carboy has sufficient space in the neck for expansion. If the IW liquid waste is being frozen, ensure adequate space is always available for expansion of the frozen liquid to prevent a rupture of the carboy.
- 13.4.8.12 Complete the Waste Estimate Tag once a carboy is "filled".
 - 13.4.8.12.1. Record the fill date and estimated activity.
 - 13.4.8.12.2. If not rendered legally non-infectious, ensure label includes international biohazard symbol.
- 13.4.8.13 Compile all Radioisotope Use Record cards relating to waste in the container and contact the RSO of to pick up the carboy.
 - 13.4.8.13.1. NOTE: Provide the original card if the pickup is the last for a particular stock vial. Provide a copy of the card if any RAM from the stock vial remains in the laboratory.
- 13.4.9 Infectious Waste (IW) Solids Half-life \leq 120 days
 - 13.4.9.1 CAUTION: BIOHAZARD AND/OR INFECTIOUS WASTE SHALL BE RENDERED NON-INFECTIOUS OR SAFE FOR GENERAL HANDLING IN ACCORDANCE WITH PROCEDURES APPROVED BY THE IBC PRIOR TO DISPOSAL THROUGH THE RSO of.
 - 13.4.9.2 IW solid waste is RAM waste also containing an infectious agent as defined under OEPA regulations and may be generated if zoonotic or infectious agents and their associated biologicals are used in association with RAM.
 - 13.4.9.2.1. Contact the institutional biosafety office for assistance in determining if the waste to be generated is infectious.
 - 13.4.9.3 The following three subparagraphs outline the ultimate disposal method for IW solid waste with a radioactive half-life \leq 120 days.
 - 13.4.9.3.1. IW solid waste rendered legally non-infectious or safe for general handling will be handled as radioactive waste based on its half-life classification and physical/chemical form.

AU MANUAL

- 13.4.9.3.2. IW solid waste that is held for decay-in-storage and is no longer radioactive will be returned to the generating facility for proper disposal through the institutional infectious waste disposal program.
- 13.4.9.3.3. IW solid waste that cannot be legally rendered non-infectious shall be placed in bags that are red in color or be placed in containers that are conspicuously labeled with the international biohazard symbol on two opposite sides.
- 13.4.9.4 Never place sharps into an IW solid waste bag. See Section **13.4.11** for information on disposing of sharps.
- 13.4.9.5 Double bag IW solid waste that is likely to become putrescent if not frozen or refrigerated.
 - 13.4.9.5.1. Each bag is restricted from containing radionuclides from more than one half-life classification, unless approved in writing on an AU's authorization by the RSO and/or RSC.
- 13.4.9.6 Prior to adding any IW solid waste to a bag, partially complete a Waste Estimate Tag.
 - 13.4.9.6.1. Record the AU name, radionuclide, and start fill date.
 - 13.4.9.6.2. White "IW Waste" on the tag so it is clearly seen.
 - 13.4.9.6.3. Clearly label IW solid waste containers with the international biohazard symbol on two opposite sides of the container.
- 13.4.9.7 Securely close the bag using a twist tie, tie wrap, or tape when no more IW solid waste is expected to be added to the bag.
- 13.4.9.8 Complete the Waste Estimate Tag after sealing the bag.
 - 13.4.9.8.1. Record the estimated activity and fill date and attach to the bag.
 - 13.4.9.8.2. Ensure "IW Waste" is clearly written on the tag.
- 13.4.9.9 Render the waste non-infectious or safe for general handling in accordance with IBC procedures before preparing for RSO pickup.
 - 13.4.9.9.1. If rendered legally non-infectious, remove or deface the biohazard markings on the container in accordance with institution biosafety office instructions.
- 13.4.9.10 Compile all the Radioisotope Use Record cards relating to waste in the container and contact the RSO to pick up the bag.
 - 13.4.9.10.1. NOTE: Provide the original card if the pickup is the last for a particular vial. Provide a copy of the card if any RAM from the vial remains in the laboratory.
- 13.4.9.11 At the time of waste pickup, the RSO shall place the IW solid waste into a plastic pail lined with a plastic bag.
 - 13.4.9.11.1. If the IW waste is a large animal or other IW solid waste that cannot fit into a pail, the RSO will use other appropriate containers or means to handle and transport the waste.
- 13.4.10 Infectious Waste (IW) Solids Half-life > 120 days
 - 13.4.10.1 CAUTION: BIOHAZARD AND/OR INFECTIOUS WASTE SHALL BE RENDERED NON-INFECTIOUS IN ACCORDANCE WITH PROCEDURES APPROVED BY THE

AU MANUAL

IBC PRIOR TO DISPOSAL THROUGH THE RSO_f.

13.4.10.2 NOTE: SOLID IW RADIOACTIVE WASTE WITH A HALF-LIFE > 120 DAYS THAT CANNOT BE LEGALLY RENDERED NON-INFECTIOUS MUST HAVE HAD A DISPOSAL METHOD IDENTIFIED PRIOR TO ITS GENERATION. IF IW SOLID WASTE IS GENERATED WITHOUT A DISPOSAL METHOD IDENTIFIED, THE RSO_f WILL COOPERATE WITH THE AU AND APPLICABLE BIOSAFETY OFFICE TO TRY TO IDENTIFY A DISPOSAL METHOD, BUT THE COST OF THE DISPOSAL WILL REST WITH THE AU AND/OR THE AU'S DEPARTMENT.

13.4.10.3 IW solid waste is RAM waste also containing an infectious agent as defined under OEPA regulations and may be generated if zoonotic or infectious agents and their associated biologicals are used in association with RAM.

13.4.10.3.1. Contact the institutional biosafety office for assistance in determining if the waste to be generated is infectious.

13.4.10.4 Properly treated radioactive IW waste that is legally rendered non- infectious in accordance with IBC procedures shall be packaged and disposed through the RSO_f as radioactive waste based upon its half-life classification and physical/chemical form. Refer to previous sections of the AU Manual.

13.4.11 Packaging instructions for sharps and sharp objects

13.4.11.1 Sharp objects are defined as any object that has the potential to puncture or lacerate, including but not limited to nails, sewing needles, straight pins, staples, metal screws, hard plastic, glass, broken ceramics, and infectious waste "sharps" as defined below.

13.4.11.2 Infectious waste "sharps" is "sharps" waste used in the treatment, diagnosis, or inoculation of human beings or animals or that have, or are likely to have, come in contact with infectious agents in medical, research, or industrial laboratories, including, without limitation, hypodermic needles and syringes, scalpel blades, and glass articles that have been broken.

13.4.11.3 Place non-infectious sharp objects into a rigid, puncture-resistant containment before placing in the waste bag.

13.4.11.3.1. Rigid cardboard lined with plastic bag meets the minimum requirement. A small plastic carboy that can be securely closed is also acceptable.

13.4.11.3.2. Clearly mark the special container with the word "SHARPS".

13.4.11.3.3. Sharp objects may not be placed in a bag with PT waste.

13.4.11.4 Place infectious sharp objects into a container specifically designed and manufactured for the management and/or disposal of sharps.

13.4.11.4.1. Ensure the container is labeled with the international biohazard symbol and the word "SHARPS".

13.5 Recycled Lead

13.5.1. Metallic lead, used for RAM shielding ("pigs", bricks, sheets), is classified as a Toxicity Characteristic Waste identified with the D008 hazardous waste code for disposal.

13.5.2. Lead no longer needed shall be surveyed with an appropriate survey meter and shall have a wipe test performed to determine if the lead is contaminated.

AU MANUAL

13.5.3. If lead is not radioactively contaminated.

13.5.3.1. Remove or deface any radiation labels.

13.5.3.2. Package lead in a container strong enough to withstand the weight of the lead and in packages not to exceed forty (40) pounds.

13.5.3.3. Request pickup with next RSO of waste pick-up.

13.5.4. If the lead is radioactively contaminated, it is considered a mixed waste requiring special handling.

13.5.4.1. Contact the RSO of for special instructions and assistance.

13.5.4.2. With the assistance/guidance of the RSO of, reasonable attempts will be made to remove the radioactive contamination (e.g., decay-in-storage, wiping or washing).

13.6. Uranium and Thorium Waste

13.6.1 Although many uranium and thorium compounds (e.g., uranyl acetate and thorium nitrate) can be purchased as non-RAM, they must be disposed of as radioactive waste.

13.6.2 Unused chemical stock materials of uranium and thorium may be removed from the laboratory by contacting the RSO of and requesting a pickup of the uranium or thorium waste.

13.7. Old RAM Waste in Laboratory

13.7.1 AUs are encouraged to dispose of RAM as soon as it is no longer useful.

13.7.2 “Old RAM” in the laboratory or on the quarterly RAM inventory report are identified as follows:

13.7.2.1. RAM which has decayed to background levels.

13.7.2.2. RAM in the L1, L2, or L3 categories > 1 year old or L4 > 3 years old.

13.7.3 RAM identified as “old RAM” should be investigated. If the material is no longer useful, contact the RSO of and request a waste pickup.

13.8. Record-Keeping for Radioactive Waste

13.8.1. Radioactive Waste Container Log Sheet

13.8.1.1. As waste is added to a waste container, laboratory personnel shall maintain a log sheet of waste deposited into the container. RS Form 3, “RADIOACTIVE WASTE CONTAINER LOG SHEET” or an equivalent form generated by the laboratory shall be used.

13.8.1.2. While waste is being added to a container the RS Form 3 or equivalent log sheet must be attached to the container, or the location must be clearly indicated on the Waste Estimate tag.

13.8.1.3. The RS Form 3 or equivalent log sheet should be used by laboratory personnel to complete the Waste Estimate Tag. The Waste Estimate Tag is a nuclide-by-nuclide summary of waste in the container. (The Waste Estimate Tag data is an educated estimate of activity in a container. A more exact activity will be determined by computer calculation of information on the associated Radioisotope Use Record card(s).)

13.8.1.4. The RS Form 3 or equivalent log sheet must accompany the container when it is picked up by RSO of staff.

AU MANUAL

13.8.1.5. Information to be recorded on a log sheet is the start and fill dates, (same dates as on Waste Estimate Tag), date(s) when waste was added, AU name, radionuclide(s), and estimated activity added. If the waste contains hazardous materials, the chemical and % by volume must also be listed on the log sheet. Additional information that aids in tracking RAM disposal for a particular laboratory is encouraged.

13.8.2. Radioisotope Use Record Card

13.8.2.1. Use and disposal of RAM must be maintained on a Radioisotope Use Record card.

13.8.2.2. If all RAM in a vial is used and the empty vial and all associated waste has been disposed of, the original card shall be furnished to RSO staff at the time of waste pickup.

13.8.2.3. If all RAM is not used/disposed, a copy of the card will be made indicating use and disposal up to the time of the pickup and the copy of the card shall be furnished to RSO staff.

13.8.2.4. When completing the Radioisotope Use Record card, the sum of all uses should add up to 100%. In addition, for each use entry, the sum of all waste types and RAM placed into reuse must equal 100%.

13.8.3. Waste Estimate Tag

13.8.3.1. Prior to RAM being added to a waste container, record general information on the Waste Estimate tag: At a minimum record the AU name, the radionuclide(s) and the start fill date. The tag shall then be attached to the waste container.

13.8.3.2. A completed Waste Estimate tag shall be attached to a container for the waste to be picked up by the RSO. (The Waste Estimate Tag data is an educated estimate of waste in the container. A more exact activity will be determined by computer calculation of information on the Radioisotope Use Record cards.)

13.8.3.3. The following information must be on the Waste Estimate Tag.

13.8.3.3.1. Start fill date (date container started being used)

13.8.3.3.2. Each radionuclide

13.8.3.3.3. Estimated activity for each radionuclide

13.8.3.3.4. Fill date (date container filled)

13.8.3.3.5. List of all AUs whose waste is present in the waste container.

13.8.3.4. For liquid waste, the information on the Waste Estimate Tag should also include a list of the major chemical components and any hazardous chemical component (list of chemicals and percentage by volume in waste)

13.8.3.5. For liquid scintillation fluid the information on the Waste Estimate Tag should also include a list of the trade name(s) of the liquid scintillation cocktails.

13.8.3.6. For additional hazards (i.e., infectious, pathological, or hazardous) the Waste Estimate Tag should also include respectively "IW Waste", "PT Waste", or "HL Waste".

13.9. Equipment Release Surveys

13.9.1. Equipment containing a radioactive source (e.g., liquid scintillation counters, gas chromatographs, spectrometers) must have the radioactive source removed prior to transfer

AU MANUAL

to a non-RAM use area or disposal.

13.9.1.1. Contact the RSO of for assistance in making arrangements to remove the source for transfer or disposal of the equipment.

13.9.1.2. Prior to transfer or disposal of the equipment, contact the RSO of to conduct a confirmatory release survey

13.9.1.3. The AU is responsible for any cost associated with disposal or return to the vendor of the radioactive source.

13.9.2. Equipment that is used to store or manipulate RAM (e.g., refrigerators, centrifuges, water baths, etc.) is considered to be potentially contaminated until proven otherwise by a proper radiological survey.

13.9.2.1. Equipment that has come into contact with RAM must be surveyed and decontaminated by laboratory personnel.

13.9.2.1.1. Prior to transfer to a non-RAM use area or disposal of the equipment, contact the RSO of to conduct a confirmatory release survey.

14. RECORDKEEPING AND REPORTS

14.1. General Records and Retention Times

14.1.1. Record keeping is an integral part of establishing and maintaining a Radioactive Material Use Authorization. By regulation, all AUs and/or the RSO of are required to maintain the following records as a minimum for the time period indicated.

14.1.2. Record retention

14.1.2.1. Most AU/laboratory generated records must be maintained for three (3) years.

14.1.2.2. Records of laboratory specific training must be maintained as long as the individual is a RAM RW under the AU.

14.1.2.3. The regulatory retention requirements for common records that may be generated by an AU are:

14.1.2.3.1. Radionuclide inventories including receipt, storage, and transfers for as long as the material is possessed and for a period of three (3) years following the material disposal or transfer.

14.1.2.3.2. Records of radiation survey results for a period of three (3) years from when the record was made unless the survey is used to determine the dose. If used to determine dose, the record retention period increase to until termination of the license.

14.1.2.3.3. Records of inspection results, audit results and the results of other reviews for three (3) years from when the record was made.

14.1.2.3.4. Records of instrument and equipment calibration for a period of three (3) years from when the record was made.

14.1.2.3.5. Records of package surveys performed for the receipt of RAM for three (3) years from when the record was made.

14.1.2.3.6. Dose calibrator calibration and check records and radiopharmaceutical dosage measurement records three (3) years from when the record was made.

AU MANUAL

14.1.2.3.7. Sealed source leak test records for three (3) years from the date the record was made.

14.1.2.4. Any questions regarding record retention should be addressed to the RSO of.

14.1.3. Record Availability

14.1.3.1. All records must be kept current and must be made available to the representatives of the RSO of during routine inspections, surveys or audits. These records may also be requested for review by members of the RSC, its delegates, or inspectors from the ODH.

14.1.3.2. All incident reports shall be maintained in a readily accessible file in the AU's laboratory.

14.2. Incident Reports

14.2.1. AU Responsibility to Report

14.2.1.1. It is imperative that all accidents, incidents and/or questionable activities and conditions involving RAM be brought to the attention of the RSO of in order that corrective actions can be taken, appropriate reviews and investigations can be conducted to assess the situation(s), and notifications, if required, can be made to appropriate UC representatives and regulatory agencies in a timely manner.

14.2.2. Categories of Incidents Requiring RSO of Notification

14.2.2.1. Examples of types of occurrences for which immediate (verbal-phone call) notification of the RSO of is required follow.

14.2.2.1.1. Personnel contamination.

14.2.2.1.2. Contamination outside a RAM use laboratory.

14.2.2.1.3. Release of RAM into sewer system.

14.2.2.1.4. Incidents involving persons who are not RWs.

14.2.2.1.5. Loss or theft of RAM.

14.2.2.1.6. Any contamination detected on the floor.

14.2.2.1.7. Any contamination greater than 1000 cpm/100 cm² on any surface outside a marked RAM work area.

14.2.2.1.8. A spill when > 100 µCi of activity was being used at the time of the spill.

14.2.2.1.9. A spill when ≤ 100 µCi of activity is being used at the time of the spill and contamination is spread to the floor or outside the marked RAM work area.

14.2.2.1.10. Contamination on a lab coat above the levels for a restricted area (see **Table 1**).

14.2.2.1.11. Incidents requiring ODH notification (see Section **14.2.3** of this manual).

14.2.2.2. The RSO of shall also be notified immediately by phone (513-558-4110) during normal working hours or 513-249-6812 (24-hour digital pager) outside normal working hours, for incidents described in Section 14.2.2. It is the responsibility of the AU to follow-up the verbal report of all incidents to the RSO of in writing using RS Form 7, "RADIATION INCIDENT REPORT".

14.2.2.3. Written incident reports must be submitted to the RSO of within five (5) working days of the incident.

14.2.2.4. Any necessary reports to appropriate regulatory agencies will be made by the RSO.

AU MANUAL

14.2.3. Categories of Incidents Requiring ODH Notification

14.2.3.1. In accordance with the RCSP policy, the RSO shall make notifications to the ODH. AUs and RAM RWs shall inform the RSO immediately upon becoming aware of or suspecting any of the following possible ODH reportable incidents may have occurred.

14.2.3.1.1. Incidents involving radiation exposures that could exceed regulatory limits (e.g., 5 rem whole body dose to a worker).

14.2.3.1.2. Incidents involving releases of RAM that could exceed regulatory limits. These events may include, but are not limited to fires, explosions, toxic gas releases in RAM use areas.

14.2.3.1.3. Lost, stolen, or missing RAM. (Commonly used radionuclides and associated activities that require immediate reporting are listed in **Table 7 - Reportable Quantities of Common Radionuclides.**)

Table 8 - Reportable Quantities of Common Radionuclides

Radionuclide	OAC 3701:1-38-18 Appendix A Quantity	Immediately Reportable Quantity
C-14	0.1 mCi	10 mCi
H-3	1 mCi	100 mCi
I-125 and I-131	0.001 mCi	0.1 mCi
P-32	0.01 mCi	1 mCi
P-33	0.1 mCi	10 mCi
S-35	0.1 mCi	10 mCi

14.2.3.1.4. A package containing a shipment of RAM that has removable surface contamination or external radiation levels that exceed regulatory limits.

14.2.3.1.5. An event involving loss of control of RAM that may have caused or threatens to cause an individual to exceed a regulatory dose limit.

14.2.3.1.6. An event involving contamination that requires access to workers or the public to be restricted for more than 24 hours.

14.2.3.1.7. An event that requires medical treatment of an individual who has spreadable contamination on his/her clothing or body.

14.2.3.1.8. An unplanned fire or explosion damaging any RAM, device, container, or equipment containing RAM.

14.2.3.1.9. A medical event as defined in OAC 3701:1-58-101.

14.2.4. In addition to any phone reporting, a written report must be submitted to the ODH within 30 days. The RSO shall prepare and submit the report. AUs and RAM RW shall work with the RSO to ensure all necessary information is provided in a timely manner and the report is submitted as required.

15. LABORATORY EMERGENCY PROCEDURES

15.1. RSO Authority

15.1.1. The RSO is authorized by the RSC to act independently to take prompt remedial action in emergency situations involving RAM. Such action will be taken only upon the determination

AU MANUAL

by the RSO that conditions present imminent danger or threat to personnel, property or the general public.

15.1.2. Actions taken by the RSO in emergency situations shall be considered temporary expedients and may include, but not necessarily be limited to the following.

15.1.2.1. Suspension of work with RAM.

15.1.2.2. Establishment of exclusion/limited access areas.

15.1.2.3. Removal of personnel from affected areas

15.1.2.4. Requirement for immediate bioassays of involved individuals.

15.2. Emergency Plan

15.2.1. Each AU is required to have a plan which incorporates laboratory-specific procedures to be implemented in the event of an emergency.

15.2.2. For the purposes of these procedures, an "emergency" may involve spills, minor and major fires, contamination incidents, accidents resulting in injury to personnel, and the creation of any condition(s) that result in a real or potential threat to the health and safety of personnel and/or the general public.

15.2.3. The laboratory emergency plan (e.g., RS Form 34, "EMERGENCY PROCEDURES – INCIDENTS INVOLVING RADIOACTIVE MATERIAL") and RS Form 19, "EMERGENCY NOTIFICATION", or its equivalent, shall be posted in the laboratory for quick reference in the event of an emergency.

15.2.3.1. It is recommended that the emergency plan (e.g., RS Form 34) be posted over the phone or at the door of the laboratory so it is a ready reference in case of an emergency.

15.2.3.2. It is recommended that RS Form 19 be posted on the door (outside) as a ready reference of who to contact for persons outside the room who notice an emergency inside the room.

15.2.4. An AU may use the procedures on the following pages or develop his/her own emergency plan. The RSC approved summary (RS Form 34, "EMERGENCY PROCEDURES INCIDENTS INVOLVING RADIOACTIVE MATERIAL") may be used as the laboratory emergency plan. If the AU develops his/her own plan, the full plan must be submitted to the RSO for review. The full emergency plan should be reviewed and amended as needed by the AU and the RAM RWs in the laboratory prior to adoption as laboratory procedure.

15.3. Sample Emergency Procedures

15.3.1. Each emergency will be different which precludes writing an exact procedure that fits every situation; however, general actions that do apply to all situations are provided. Carry out the actions applying radiation safety principles to the situation at hand.

15.3.2. An acceptable one-page summary of emergency procedures suitable for posting in laboratories is included as RS Form 34, "EMERGENCY PROCEDURES INCIDENTS INVOLVING RADIOACTIVE MATERIAL".

15.4. Accidental Spills Procedure

15.4.1. Having a spill kit with decontamination supplies readily available is required so personnel are prepared to handle a spill when it occurs. Suggested items in a spill kit include:

AU MANUAL

Yellow plastic bags	Notepad/paper and pen
Absorbent paper or rags	Markers and grease pencils
Barrier materials	Tongs
Scrub brushes	Gloves and shoe covers
Swipes	Detergents
Tape	Sharps container

15.4.2. The amount of materials will vary between laboratories. If only a few milliliters or a few microcuries of RAM are used, a smaller spill kit is required as compared to a laboratory which uses liters or millicuries.

15.4.3. IN THE EVENT OF AN ACCIDENTAL SPILL OF RAM, THE FOLLOWING PROCEDURE SHOULD BE CARRIED OUT:

IMMEDIATE ACTIONS

S Stop the spill. Contain the spill to facilitate decontamination efforts and reduce overall dose to individuals and damage to the environment.

W Warn others in the area that a spill has occurred. Evacuate if necessary. Notify the RSO.

I Isolate the area to keep people from entering without proper precautions. Verify boundaries to ensure the spill is contained.

M Minimize exposure. Move away from sources. Remove contamination from individuals by decontaminating and/or removing clothing items.

15.4.4. Utilize materials from the laboratory spill kit to stop and contain the spill. A proper spill kit will have enough materials to stop and contain the spilled material for the worst-case scenario for a particular laboratory.

15.4.5. Seek assistance after everyone in the immediate area has been warned and knows the spill location. Call or direct someone to call the RSO. Inform the RSO as to the nature of the spill, the location (room number), identity of the radionuclide(s), a realistic estimate of the activity, and the chemical or physical form. RSO personnel will respond, evaluate the extent of the problem, and assist if necessary.

15.4.6. Isolate the area by shutting doors and/or placing barriers to prevent inadvertent entry into the spill area. Use RAM warning labels, chalk, tape, or rope to clearly mark the spill area. A survey should be performed as soon as possible directly outside the spill area boundaries to verify that the contamination is in fact isolated.

15.4.7. Check for contamination of personnel. Decontaminate immediately if any personnel contamination is detected using procedures in Section 12.1.1 of this manual. Flush with plain cool or lukewarm water first, then use soap and water. Any methods harsher than these should be performed under medical supervision.

15.4.8. Commence cleanup wearing two pairs of protective gloves and other PPE. Blot the spilled liquid with absorbent paper. Do not wipe or use a wiping motion, as this may enlarge the area of the spill. Avoid stepping in the spilled liquid. Shoe covers should be worn to avoid contamination of shoes. Survey and document each decontamination effort.

AU MANUAL

- 15.4.9. If surveys indicate a more aggressive cleanup is required, refer to Section **12.1.2** of this manual. Levels shall be reduced to below the action levels in **Table 1** and should be reduced to below 100 cpm above background for ALARA purposes.
- 15.4.10. Store contaminated clothing and other items in an appropriate container. Wear protective gloves when handling such items.
- 15.4.11. Perform bioassays on anyone who was contaminated (even if all contamination was removed).
- 15.5. Spill Reported Late
 - 15.5.1. Refer to RSC Policy 98-2.
 - 15.5.2. The following action shall be taken if a spill involving widespread contamination occurs, or a spill or incident required to be reported immediately (per Section 14.2.2 of this manual) is not reported to the RSO in what the RSO believes is a timely manner. (For most incidents, “timely” means within four (4) hours of an individual becoming aware an incident has occurred.)
 - 15.5.2.1. The RSO shall inform the RSC Chair of the incident.
 - 15.5.2.2. The RSC Chair shall designate an incident investigation subcommittee that shall include:
 - 15.5.2.2.1. RSC Chair.
 - 15.5.2.2.2. Two RSC voting members.
 - 15.5.2.2.3. Applicable administrative representative to the RSC.
 - 15.5.2.2.4. The RSO.
 - 15.5.2.3. The subcommittee shall meet to review the incident within 30 days of the incident.
 - 15.5.2.4. The subcommittee shall invite the AU to the meeting.
 - 15.5.2.5. The subcommittee shall review the RSO’s investigation and/or recommendations, and implement any disciplinary action. Disciplinary action may include, but is not limited to:
 - 15.5.2.5.1. First incident: requiring training on contamination control and/or contamination detection.
 - 15.5.2.5.2. Second incident: suspending the authorization for a period of 30 days along with requiring training on contamination control, contamination detection, and/or spill response.
 - 15.5.2.5.3. Third incident: suspending the authorization for a period of 6 months along with requiring training on contamination control, contamination detection and/or spill response.
 - 15.5.2.5.4. In determining if the situation is a first, second or third incident a period of time of 2 years prior to the date of the current incident shall be used.
 - 15.5.3. The RSO shall keep the RSC informed about spills by routinely providing information about incidents in the RSO Report present during each RSC meeting or as requested by the RSC.
- 15.6. Laboratory Fire Emergency Procedures
 - 15.6.1. In the event of fire in a RAM laboratory, employees at UC call 911; at CCHMC call the general emergency number, 513-636-8877; and at SHC call the general emergency number

AU MANUAL

5555, to report a fire.

15.6.2. Large Fires

- 15.6.2.1. Vacate the room or area IMMEDIATELY. Sound the fire alarm, notify the fire department and the RSO of.
- 15.6.2.2. Once in a safe location, you and other involved persons, including fire fighters, MUST NOT LEAVE THE GENERAL AREA without approval from the RSO of.
- 15.6.2.3. DO NOT re-enter, or allow others to re-enter, the room or area after the fire has been brought under control or extinguished until approval to do so has been obtained from the RSO of.

15.6.3. Small Fires

- 15.6.3.1. Have someone nearby sound the fire alarm and notify the fire department and the RSO of. If no one is nearby, sound the alarm yourself, call the fire department and the RSO of.
- 15.6.3.2. Use the fire extinguisher to extinguish the fire, or use a fire blanket, or other suitable means to smother the fire. DO NOT beat or flail at the fire. (Note: use of fire extinguishers requires training. Do not use a fire extinguisher unless you have been trained and you feel comfortable using the fire extinguisher.)
 - 15.6.3.2.1. DO NOT disturb the shielding around RAM or its storage container.
 - 15.6.3.2.2. If your safety or that of others is not threatened, TURN OFF electrical equipment and secure any systems that may support combustion (e.g., gas or oxygen).
 - 15.6.3.2.3. Stay between the fire and the exit.
 - 15.6.3.2.4. Keep all unnecessary persons out of the room or area during the fire and after the fire is extinguished.
 - 15.6.3.2.5. After the fire is extinguished, remain in the area until released by the RSO of and the Fire Department.

15.6.4. IF THE FIRE INVOLVES OR SPREADS TO RAM

- 15.6.4.1. With all others, vacate the room or area and close the door.
- 15.6.4.2. Inform the RSO of as to the amount of radioactivity involved or which may be involved.
- 15.6.4.3. Do not leave or allow others to leave the general area, or allow reentry after the fire has been extinguished until approval to do so has been obtained from the RSO of and the Fire Department.

15.7. Skin Contamination

- 15.7.1. If you suspect or detect skin contamination, notify the RSO of immediately.
 - 15.7.1.1. Perform a survey and record the survey results.
 - 15.7.1.2. Perform decontamination, as outlined in Section 12.1.1 of this manual. Perform survey and record survey results between each decontamination attempt.

15.8. Internal Contamination

- 15.8.1. If you suspect that internal contamination has occurred, notify the RSO of immediately.
- 15.8.2. Estimate and record the activity internalized, chemical and physical form, route, and time of

AU MANUAL

contamination. Provide this information to the RSO of so a decision for proper diagnostic and/or corrective measures can be made as soon as possible.

15.9. Medical Emergencies Involving RAM

15.9.1. If a medical emergency involving RAM occurs, notify the RSO of and appropriate Security and Emergency Care representatives.

15.9.2. Assist people first; worry about RAM contamination second.

15.9.3. Report to the RSO of and medical response personnel any RAM located in the room and/or on the clothing or the person(s) needing medical attention.

AU MANUAL

APPENDIX I: LIST OF RADIATION SAFETY FORMS

RS FORM 2.0	RADIATION WORKER/DOSIMETRY APPLICATION
RS FORM 2.1	DOCUMENTATION OF AU LAB SPECIFIC RADIATION WORKER TRAINING/INTERVIEW
RS FORM 3	RADIOACTIVE WASTE CONTAINER LOG SHEET
RS FORM 4	NON-COMPLIANCE RESPONSE FORM
RS FORM 6	APPLICATION FOR NON-HUMAN USE OF RADIOACTIVE MATERIAL
RS FORM 6.1	STATEMENT OF PRIOR TRAINING AND EXPERIENCE
RS FORM 7	RADIATION INCIDENT REPORT
RS FORM 10A	RAM TRANSFER REQUEST
RS FORM 12	AUTHORIZED USER ROUTINE LABORATORY SURVEY REPORT
RS FORM 14	RADIOACTIVE MATERIAL REQUEST
RS FORM 19	EMERGENCY NOTIFICATION
RS FORM 24	DECOMMISSIONING OF RAM-USE ROOM
RS FORM 30	APPLICATION FOR <u>CLINICAL</u> HUMAN-USE OF RADIOACTIVE MATERIAL
RS FORM 31	APPLICATION FOR <u>INVESTIGATIONAL</u> HUMAN-USE OF RADIOACTIVE MATERIAL
RS FORM 32	RADIOIODINE USERS SHEET - UNSEALED SOURCES ONLY
RS FORM 33	DECLARATION OF PREGNANCY
RS FORM 34	EMERGENCY PROCEDURES - INCIDENTS INVOLVING RADIOACTIVE MATERIAL
RS FORM 35	APPLICATION FOR AUTHORIZED MEDICAL PHYSICIST
RS FORM 36	TRUSTWORTHY AND RELIABILITY
RS FORM 36A	EXPANDED BACKGROUND SCREEN INFORMATION
RS FORM 37	RESPONSIBLE ADMINISTRATOR FOR FIXED RAM CONTAMINATED SPACE
RS FORM 38	RELEASE OF LIABILITY AND WAIVER CLAIM FOR MINORS
RS FORM 38A	SUPERVISOR'S STATEMENT FOR MINORS

**COPIES OF FORMS ARE AVAILABLE
FROM THE RADIATION SAFETY OFFICE (513-558-4110)**

or

**ON THE RADIATION SAFETY WEBSITE AT
[HTTPS://RESEARCH.UC.EDU/SUPPORT/OFFICES/RADSAFETY/OVERVIEW](https://research.uc.edu/support/offices/radsafety/overview)**

AU MANUAL

APPENDIX II: GLOSSARY OF TERMS

AAPM American Association of Physicists in Medicine

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

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

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

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

AU Authorized User

AMP Authorized Medical Physicist

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

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

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

Brachytherapy source means an individual sealed source or a manufacturer-assembled source train that is not designed to be disassembled by the user and which is to be used for brachytherapy.

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

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

CFR Code of Federal Regulations

CCHMC Cincinnati Children's Hospital Medical Center

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

AU MANUAL

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

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

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

CPM Counts Per Minute

Declared pregnant woman means a woman who has voluntarily informed the licensee, 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.

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

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

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

DOT United States Department of Transportation DPM Disintegrations Per Minute

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

EDS Eating, Drinking, or Smoking

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

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

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

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

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

HDR High Dose Remote Afterloader

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

IAEA International Atomic Energy Agency IBC Institutional Biosafety Committee

Individual monitoring devices (individual monitoring equipment) means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescence dosimeters (TLDs), pocket ionization chambers, and personal ("lapel") air sampling devices.

IRB Institutional Review Board

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

AU MANUAL

the body.

Lens dose equivalent (LDE) applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm²)

Lost or missing licensed material means licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

Member of the public means any individual except when that individual is receiving an occupational dose.

Minor means an individual less than 18 years of age

NCRP National Council on Radiation Protection.

Nonstochastic effect means health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect (also called a deterministic effect).

NRC United States Nuclear Regulatory Commission

Occupational dose 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 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 in accordance with ODH rules, from voluntary participation in medical research programs, or as a member of the public.

OAC Ohio Administrative Code

OEPA Ohio Environmental Protection Agency

ODH Ohio Department of Health

ORC Ohio Revised Code

OSL Optically Stimulated Luminescence dosimeter

PPE Personal Protective Equipment

Public dose means the dose received by a member of the public from exposure to radiation, or radioactive material released by a licensee, or to any other source of radiation under the control of a licensee. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with ODH rules, or from voluntary participation in medical research programs.

QA Quality Assurance

QMP Quality Management Program

Quality factor (Q) means the modifying factor (listed in ODH rule 3701:1-38) that is used to derive dose equivalent from absorbed dose.

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

Radiation (ionizing radiation) means alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this manual, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

AU MANUAL

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

Radioactive Waste is any radioactive material (RAM) or items that contain or are contaminated with RAM that are no longer useful.

RAM Radioactive Material

RCRA Resource Conservation and Recovery Act

RCSP Radiation Control and Safety Program

RDRC Radioactive Drug Research Committee

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

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

RGE Radiation Generating Equipment

RS Radiation Safety

RSC Radiation Safety Committee

RSO Radiation Safety Officer

RSOf Radiation Safety Office

RW Radiation Worker

SHC Shriner's Burns Hospital for Children

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

Shallow-dose equivalent (H_s), which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2) averaged over an area of 1 square centimeter.

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

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

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

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

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

TEDE Total Effective Dose Equivalent

AU MANUAL

TLD Thermoluminescent Dosimeter

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

UC University of Cincinnati

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

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

Very high radiation area means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or 1 meter from any surface that the radiation penetrates.

Weighting factor (W_T), for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of W_T for various organs or tissue are in OAC 3701:1-38.

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

AU MANUAL

APPENDIX III: RULES OF THUMB

Beta Particles

Beta particles of at least 70 keV energy are required to penetrate the nominal protective layer of the skin (7 mg/cm^2 or 0.07 mm).

The average energy of a beta-ray spectrum is approximately one-third the maximum beta energy of the nuclide.

The range of beta particles in air is approximately 12 ft/MeV. (The maximum range of a P-32 beta is $1.71 \text{ MeV} \times 12 \text{ ft/MeV}$ or approximately 20 feet.)

The dose rate in rad per hour in a solution by a beta emitter is $2.12 EC/\rho$ where E is the average beta energy per disintegration in MeV, C is the concentration in microcuries per cubic centimeter ($\mu\text{Ci/cc}$), and ρ is the density of the medium in grams per cubic centimeter (g/cc). The dose rate at the surface of the solution is one-half the value given by this relation. (For P-32, with an average energy of about 0.7 MeV, the dose rate from $1 \mu\text{Ci/cc}$ in water is about 1.48 rad/hr.)

The surface dose rate through the nominal protective layer of the skin from a uniform thin deposition of $1 \mu\text{Ci/cm}^2$ is about 9 rad/hour for energies above about 0.6 MeV. Note that in a thin layer, the beta dose rate exceeds the gamma dose rate, for equal energies released, by a factor of about 100.

For a point source of beta radiation (neglecting self and air absorption) of a given strength in millicuries, the dose rate at 1 cm is approximately equal to $300 \times \text{mCi rad/hour}$ and varies only slightly with beta energy. The dose rate for 1 mCi of P-32 at 1 cm is approximately 300 rad/hour.

Plastics are excellent shields for beta emitters.

Gamma Rays and X-rays

For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate (mR/hr) within $\pm 20\%$ at 1 foot is $6 \times \text{mCi} \times E \times n$, where mCi is the number of millicuries; E, the energy in MeV; n is the number of gammas/disintegration.

The dose rate to tissue in rad per hour in an infinite medium uniformly contaminated by a gamma emitter is $2.12 EC/\rho$; where C is the number of microcuries per cubic centimeter, E is the average gamma energy per disintegration (MeV), and ρ is the density of the medium. At the surface of a large body, the dose rate is about half of this.

Lead is an excellent shield for x and gamma ray emitters.

Miscellaneous

The activity of any radionuclide is reduced to less than 1% after 7 half-lives.

For material with a half-life greater than six days, the change in activity in 24 hours will be less than 10%.

AU MANUAL

APPENDIX IV: DEFINITION OF MEDICAL EVENT AND REPORTABLE DOSE TO EMBRYO/FETUS OR NURSING CHILD

Medical Event (refer to OAC 3701:1-58-101) means any event, except for an event that results from patient intervention, in which radioactive material or radiation from radioactive material results in

1. A dose that differs from the prescribed dose or dose that would have resulted from the prescribed dosage by more than 0.05 sievert, or five rem effective dose equivalent, 0.5 sievert, or fifty rem to an organ or tissue, or 0.5 sievert, or fifty rem shallow dose equivalent to the skin; and
 - a. The total dose delivered differs from the prescribed dose by twenty percent or more;
 - b. The total dosage delivered differs from the prescribed dosage by twenty percent or more or falls outside the prescribed dosage range; or
 - c. The fractionated dose delivered differs from the prescribed dose, for a single fraction, by fifty percent or more.
2. A dose that exceeds 0.05 sievert, or five rem effective dose equivalent, 0.5 sievert, or fifty rem to an organ or tissue, or 0.5 sievert, or fifty rem shallow dose equivalent to the skin from any of the following:
 - a. An administration of a wrong radioactive drug containing radioactive material;
 - b. An administration of a radioactive drug containing radioactive material by the wrong route of administration;
 - c. An administration of a dose or dosage to the wrong individual or human research subject;
 - d. An administration of a dose or dosage delivered by the wrong mode of treatment; or
 - e. A leaking sealed source; or
3. A dose to the skin or an organ or tissue other than the treatment site that exceeds by 0.5 sievert or fifty rem to an organ or tissue and fifty percent or more of the dose expected from the administration defined in the written directive (excluding, for permanent implants, seeds that were implanted in the correct site but migrated outside the treatment site).

Reportable dose to embryo/fetus or nursing child (refer to OAC 3701:1-58-102) means

1. Any dose to a embryo/fetus that is greater than fifty millisievert or five rem dose equivalent that is a result of an administration of radioactive material or radiation from radioactive material to a pregnant individual unless the dose to the embryo/fetus was specifically approved, in advance, by the authorized user.
2. Any dose to a nursing child that is a result of an administration of radioactive material to a breast-feeding individual that:
 - a. Is greater than fifty millisievert, or five rem total effective dose equivalent; or
 - b. Has resulted in unintended permanent functional damage to an organ or a physiological system of the child, as determined by a physician.

AU MANUAL

APPENDIX V: POINT SYSTEM

SIGNS AND POSTING

Points	Infraction Description Assessed
(1)	ODH "Notices to Employees" not posted in laboratory
(5)	RAM incident/emergency procedures not posted in laboratory
(10)	Laboratory door not labeled "Caution RAM"(e.g., sign removed and not replaced)
(10)	No documentation of radiation worker notification of non-compliances or audits/surveys reports(from current or the previous semi-annual period)indicating non-compliances not posted.
(10)	Areas of RAM use within laboratory not labeled "Caution RAM" (e.g., bench areas, hood, centrifuge, or other equipment)
(10)	RAM storage areas not labeled "Caution RAM" (e.g., refrigerators, freezers, cabinets)
(25)	Maximum assessment for either incomplete labeling of RAM waste containers or incomplete labeling of stored RAM (i.e., not properly labeled with all 5 required items). Individual items missing are assessed according to the following schedule: (2) no "Caution RAM" label (2) no indication of radionuclide(s) present (2) no activity(s) indicated (2) no reference date for activity (2) no AU name or reference
(15)	A radiation area (> 5 mR/hr) not labeled "Caution, Radiation Area"
(75)	A high radiation area (> 100 mR/hr) not labeled "Caution, High Radiation Area"
(100)	A very high radiation area (> 500 R/hr) not labeled "Grave Danger, Very High Radiation Area"

RECORDS

Wipe test records (maximum 25 points per category per audit for wipe test records)

Points	Infraction Description Assessed
(1)	per month for failure to document nonuse of RAM prior to audit
(5)	per week for each missing weekly survey (e.g., missed for 2 labs, same week = 5 pts)
(5)	per month for each missing monthly survey (e.g., missed for 2 labs, same month = 5 pts)

Inventory records

Points	Infraction Description Assessed
(5)	no record of RAM inventory available in the laboratory (e.g., use card(s) for each RAM item or printed inventory summary not available)
(5)	inventory not submitted at scheduled submission date (i.e., by 15 th of January, April, July, or October unsealed RAM and by 15 th of February, May, August, or November for sealed sources)
(10)	failure to submit inventory in a timely manner after reminder sent by RSO; issued every 10 working days after reminder sent ("reminder" is non-compliance letter with points)

AU MANUAL

RAM ORDERING/TRANSFER/POSSESSION

Points	Infraction Description Assessed
(5)	Replacement shipment of RAM received by program (e.g., at RSO) without AU obtaining replacement shipment approval by RSO
(10)	Internal UC RCSP transfer of RAM without prior RSO approval & receiver is authorized by RSC (per authorization) to receive the RAM (i.e., RAM transferred is within the receiver's order and possession limits)
(10)	Ordering RAM without prior RSO approval and RAM order is authorized by RSC (per authorization) (i.e., order does not exceed authorization order limits or make authorization exceed possession limits)
(25)	Ordering RAM without prior RSO approval and RAM order is not authorized by RSC (per authorization) (i.e., order exceeds authorization's order limits and/or makes authorization exceed possession limits)
(25)	Use/possession of RAM without RSC approval (i.e., RAM not approved under authorization)
(25)	RAM delivered directly to the laboratory and the incident not immediately reported to RSO
(25)	Transfer of RAM outside UC's RCSP without RSO approval or review

RAM USE/STORAGE

Points	Infraction Description Assessed
(10)	RAM use in RAM laboratory/area not indicated on authorization (e.g., use in RAM laboratory listed for use under another authorization)
(20)	RAM use in laboratory/area that has not been approved for RAM use

Unsecured/unattended RAM waste*

Points	Infraction Description Assessed
(5)	activity less than or equal to quantities listed in OAC 3701:1-38-18 appendix A**
(10)	activity less than or equal to 10 times the quantities listed in OAC 3701:1-38-18 appendix A** but more than the base quantities listed in OAC 3701:1-38-18 appendix A**
(20)	activity less than 100 times the quantities listed in OAC 3701:1-38-18 appendix A** but greater than 10 times the quantities listed in OAC 3701:1-38-18 appendix A**
(25)	activity equal to or greater than 100 times the quantities listed in OAC 3701:1-38-18 appendix A**

**Sample OAC 3701:1-38-18 appendix A values: I-125(1 μ Ci); P-32(10 μ Ci); C-14, S-35 or P-33(100 μ Ci); H-3(1000 μ Ci)

Unsecured/unattended RAM stock or experimental material*

Points	Infraction Description Assessed
(10)	activity less than or equal to quantities listed in OAC 3701:1-38-18 appendix A**
(15)	activity less than or equal to 10 times the quantities listed in OAC 3701:1-38-18 appendix A** but more than the base quantities listed in OAC 3701:1-38-18 appendix A**
(20)	activity less than 100 times the quantities listed in OAC 3701:1-38-18 appendix A** but greater than 10 times the quantities listed in OAC 3701:1-38-18 appendix A**
(25)	activity equal to or greater than 100 times the quantities listed in OAC 3701:1-38-18 appendix A**

*Areas of concern will be issued if the time observed by the RSO is < 5 min., the authorization has not had a security noncompliance issued during the last 12 months, and the points for the non-compliance are \leq 20 less.

**Sample OAC 3701:1-38-18 appendix A values: I-125(1 μ Ci); P-32(10 μ Ci); C-14, S-35 or P-33(100 μ Ci); H-3(1000 μ Ci)

AU MANUAL

RAM WASTE DISPOSAL

Points	Infraction Description Assessed
(10)	Improper disposal of RAM as RAM (e.g., liquid scintillation vials as solid RAM waste)
(25)	RAM waste disposed of as non-RAM waste (e.g., RAM waste detected in regular trash container; multiple incidents in a year of contaminated sink.)

PERSONNEL

Points	Infraction Description Assessed
(5)	Failure of AU to document laboratory specific training, per RAM radiation worker (i.e., interview with RAM radiation worker indicates training was provided)
(15)	Failure of AU to provide appropriate training, per RAM radiation worker (e.g., no documented laboratory specific training or non-compliance communication and RAM radiation worker interview indicates training and/or communication was not performed)
(25)	Person using RAM who is not approved as a RAM radiation worker under UC's RCSP
(75)	Persons observed using RAM during a suspension (e.g. suspension for failure to attend retraining)

PERSONNEL MONITORING

Points	Infraction Description Assessed
(5)	Personnel monitors (e.g., film badges) not picked up at RSO during first 3 working days of the month
(5)	Personnel monitors (e.g., film badges) not returned during the first 10 days of the month after use (i.e., previous month not turned in by 10 th of current month)(note: issued if entire series is missing, not an individual monitor within a series)
(5)	Follow-up notice for unreturned monitor or monitor processing problem not returned within 60 days of initial issue
(15)	ALARA notice form not completed and returned within 60 days of initial issue
(15)	Bioassay not performed as required by RCSP or authorization
(15)	Personnel monitor not used as required by RCSP or authorization and the activity in use is less than 1 millicurie
(25)	Personnel monitor not used as required by the RCSP or authorization and the activity in use is greater than or equal to 1 millicurie

GENERAL SAFETY/ALARA

RAM Use

Points	Infraction Description Assessed
(10)	Remote handling equipment not used as required by RCSP or authorization
(10)	Shielding not used as required by RCSP or authorization
(10)	Failure to cover RAM procedure area on laboratory bench with absorbent paper
(25)	Failure to use fume hood as required by RCSP or authorization
(25)	Protective clothing (i.e., laboratory coat, and gloves and/or items specifically listed in authorization) not worn as required

AU MANUAL

Survey meter

Points	Infraction Description Assessed
(10)	Survey meter not in calibration
(15)	Inoperable survey meter not labeled inoperable <u>Eating/Drinking/Smoking(EDS)</u>
(5)	Observed gum chewing in RAM use area/laboratory
(5)	Evidence of eating/drinking/use of tobacco products (EDS) or application of cosmetics in RAM use laboratory (e.g., empty soda can, food wrapper in trash)
(10)	Subsequent violation of evidence of EDS within six months
(25)	Observe placing gum in mouth in RAM use area/laboratory
(25)	Individual observed eating, drinking or using tobacco products in RAM use area/laboratory
(25)	Evidence of food/drink/tobacco product preparation in RAM use area/laboratory (e.g., getting water for tea; coffeepot in laboratory)
(25)	Storage of food, drink, tobacco product or medication in RAM use area/laboratory (e.g., coffee cup with beverage in laboratory)
(25)	Observed placing gum in mouth while in laboratory <u>Miscellaneous</u>
(5)	Decontamination supplies not available
(25)	Observed application of cosmetics in RAM use area/laboratory
(25)	Observed mouth pipetting in RAM use area/laboratory

RETRAINING

Failure to attend retraining does not result in points; it results in suspension of privileges. If any authorized user does not attend retraining during a calendar year, the authorization's ordering privileges are suspended, effective January 1, until retraining is accomplished. The RSC may also revoke the authorization if the delinquent retraining requirement is not accomplished within a reasonable time (e.g., by the first RSC meeting of the year). Any RAM radiation worker, including authorized users, who does not attend retraining during a calendar year will have their RAM radiation worker status suspended, effective January 1, until retraining is accomplished. 75 points, as noted above, are issued and the RSC must consider suspension of the authorization if a suspended RAM radiation worker is observed using RAM during the suspension.

FAILURE TO REPORT OR DETECT A SPILL

Failure to report or detect a spill in a timely manner does not result in points being issued. In accordance with paragraph 13.5, if a spill is not reported immediately to the RSO or detected in a timely manner, the authorized user is required to meet with an executive subcommittee of the RSC. The incident is reviewed and case-by-case disciplinary action determined.

AU MANUAL

APPENDIX VI: PERSONNEL DECONTAMINATION METHODS

Listed in increasing order of harshness. Begin decontamination using mild methods and progress to harsher methods only as required. Medical supervision is required for all methods harsher than the use of soap and water.

Method	Decontamination Information
Tape	<p>Common Agents: Adhesive tape, masking tape Action: Removes by adhesion of contamination to tape Advantages: Simple, useful for spot contamination Disadvantages: Not useful for area contamination</p>
Flushing	<p>Common Agents: Water Action: Removes by flushing Advantages: Removes contamination if used immediately. May be used (with medical supervision) for eyes, ears, nose, mouth, and wounds Disadvantages: When used for nose and mouth, contaminated person should be warned not to swallow rinses</p>
Mild soap and water	<p>Common Agents: Bar soap, liquid soap Action: Emulsifies, dissolves, and abrades Advantages: Readily available, effective for most cases Disadvantages: Continued washing defats skin. May spread contamination and facilitate dermal absorption.</p>
Abrasive soap and water	<p>Common Agents: Pumice-impregnated bar soap, powdered grit soap Action: Emulsifies, dissolves, and abrades Advantages: Readily available, effective for tough callused skin Disadvantages: Continued washing abrades skin. May facilitate dermal absorption.</p>
Detergent and water	<p>Common Agents: Household laundry detergents Action: Same as soap Advantages: Slightly more effective than soap Disadvantages: Will defat and abrade skin; use with care</p>
Chemical complexing	<p>Common Agents: 10% EDTA solution Action: Chelates (bonds to contaminant) Advantages: Useful for heavy metals Disadvantages: none</p>
Oxidizing agents	<p>Common Agents: Household bleach, potassium permanganate and sodium bisulfate Action: Dissolves contaminant absorbed in the epidermis Advantages: Superior for skin decontamination Disadvantages: Removes a layer of skin</p>
Sweating	<p>Action: Removes by sweating Advantages: Cleansing is from inside out Disadvantages: Contamination may seep into skin pores if profuse sweating is prolonged NOTE: Sweating is a passive, mild decontamination method that should be used when other methods have been discontinued because of skin irritation or decreased effectiveness.</p>

AU MANUAL

APPENDIX VII: EQUIPMENT/PROPERTY DECONTAMINATION METHODS

MANUAL CLEANING

Method	Decontamination Information
Tape patches	<p>Applic: Dry, localized contamination</p> <p>Advant: Inexpensive, simple</p> <p>Disadv: Useful only on small areas, can be very time-consuming</p>
Strippable coating	<p>Applic: Dry contamination; spray on coating, peel off when set</p> <p>Advant: Similar to tape patches, better suited for larger surface areas</p> <p>Disadv: None listed</p>
Vacuum cleaner (dry)	<p>Applic: Dry surfaces with loose contamination</p> <p>Advant: Good preparatory step for further decontamination; effective for dry, porous surfaces</p> <p>Disadv: Vacuum cleaner exhaust must have high-efficiency filter; contamination concentrated in collecting bag can cause dose rate concerns; Not effective for crusted deposits; airborne radioactivity may be generated</p>
Vacuum cleaner (wet)	<p>Applic: Contaminated liquids; wet spray or wash down of dry contamination</p> <p>Advant: Less risk of airborne radioactivity</p> <p>Disadv: Liquid waste generated</p>
Wet wipe or mop	<p>Applic: Dust or accumulated contamination, wipe with water or decon solution; good follow-up for vacuuming or other methods</p> <p>Advant: Versatile, simple</p> <p>Disadv: Worker intensive; may involve higher worker dose due to proximity to work</p>
Brushing	<p>Applic: Loose, crusty contamination; debris</p> <p>Advant: Preparatory step</p> <p>Disadv: Can generate airborne radioactivity; not effective for dust or fine particulates</p>
Water jet; steam jet	<p>Applic: Nonporous surfaces (metal, paint, plastic, etc.); not suitable for porous surfaces (wood, concrete, etc.)</p> <p>Advant: May be used in low-pressure hose or high-pressure jet (10,000 psi) applicators; High-pressure jets can be very effective in loosening and dissolving deposits; can quickly decontaminate large areas</p> <p>Disadv: Can drive alpha contamination into concrete; drainage must be controlled; liquid becomes contaminated; not effective on oiled surfaces; danger in handling high-pressure nozzles; airborne contamination probable</p>
Soaking, spraying	<p>Applic: Small and moderate-sized equipment</p> <p>Advant: Soaking provides good access to surfaces; many soaking agents available; spraying combines mechanical and chemical action</p> <p>Disadv: May require support equipment and systems; can produce large waste volume</p>
Ultrasonic cleaning	<p>Applic: Small parts</p> <p>Advant: Combines soaking and mechanical action; remote operation; rapid decontamination of irregular shapes and crevices</p> <p>Disadv: Not always useful for strongly absorbed or absorbed contamination</p>
Vibratory finishing	<p>Applic: Small tools</p> <p>Advant: Removes rust and gross contamination</p> <p>Disadv: Size limitation; more suitable for exposure reduction than complete decon.</p>

AU MANUAL

ABRASIVE METHODS

Method	Decontamination Information
Abrasive blasting	<p>Applic: Irregularly shaped or large surfaces where critical dimensions are not involved</p> <p>Advant: Rapid, very effective decontamination; variety of abrasives available; wet or vacuum blasting can reduce generation of airborne activity and spread of contamination</p> <p>Disadv: Usually generates airborne contamination; may spread surface contamination; grit size must be finer than surface finish</p>
Grinding	<p>Applic: Small objects or isolated spots on large objects</p> <p>Advant: Economical, effective</p> <p>Disadv: Leaves residual contamination; airborne contamination</p>
Chipping, spalling, cutting	<p>Applic: Concrete or structural surfaces</p> <p>Advant: Effective for removal of porous surfaces; removes surface in thin layers (0.3 cm per pass)</p> <p>Disadv: Leaves residual contamination; can generate airborne activity; usually slow</p>
Scabbling	<p>Applic: Concrete surfaces</p> <p>Advant: Same as for chipping and spalling; faster than chipping and spalling; can be fitted with high-efficiency filter</p> <p>Disadv: Can leave residual contamination; can generate airborne activity</p>

ELECTROCHEMICAL CLEANING

Method	Decontamination Information
Electropolishing	<p>Applic: Small tools and parts, tanks, pipes, larger surfaces</p> <p>Advant: Highly effective; can be aimed at spots; fast decontamination; remote application</p> <p>Disadv: Removes thin layer (2 mils) of base material; attacks high spots first; possible material compatibility problems with acid electrolytes</p>

CHEMICAL CLEANING

Many chemical solutions can be applied either hot or cold. Hot applications are usually more effective than cold applications.

Method	Decontamination Information
Detergents	<p>Applic: Nonporous surfaces with contamination films</p> <p>Advant: Dissolves contaminated films and oils; may be applied by rag or soaking</p> <p>Disadv: Relatively mild, may not be effective for deep-seated contamination</p>
Complexing agents (oxalates, carbonates, citrates, EDTA)	<p>Applic: Nonporous surfaces (unweathered, no rust)</p> <p>Advant: Contamination retained in solution; easily stored; carbonates and citrates are nontoxic, noncorrosive</p> <p>Disadv: Little penetrating power; not effective for weathered surfaces</p>
Organic solvents	<p>Applic: Nonporous surfaces (greased, waxed, painted, plastic-covered)</p> <p>Advant: Quick dissolving action; solvent can be removed by distillation</p> <p>Disadv: Flammable; ventilation required; toxic; not as effective as acid processes</p>
Inorganic acids	<p>Applic: Metal surfaces (porous deposits, rust, corrosion)</p> <p>Advant: Corrosive action on porous deposits</p>

AU MANUAL

	Disadv: Personnel hazard; toxic; explosive gases generated; ventilation required
Acid mixtures	Applic: Nonporous surfaces (porous deposits) Advant: Highly effective dissolving action Disadv: Weathered surfaces may require long treatment
Caustics	Applic: Painted surfaces (horizontal) Advant: Softens paint with minimum contact; easy storage Disadv: Personnel hazard; slow reaction rate; not efficient for vertical or overhead surfaces; do not use on aluminum or magnesium
Trisodium phosphate	Applic: Painted surfaces (vertical and horizontal) Advant: Softens paint Disadv: Destructive to paint; do not use on aluminum or magnesium