RADIATION SAFETY MANUAL

University of California, Berkeley

FOREWORD

Many research and instructional activities use sources of ionizing radiation as a valuable tool to extend fundamental knowledge. These activities are an important part of the University of California's contribution to the society it serves, and are critical to its mission.

The excellent safety record of the University of California, Berkeley (UC Berkeley) in its use of radiation-producing machines and radioactive materials attests to the success of its radiation safety program.

This manual describes the policies and procedures intended to ensure radiation safety on the Berkeley campus. All personnel working with ionizing radiation are required to understand and follow these policies and procedures, and must exercise proper care to prevent radiation from becoming a hazard to themselves or to others.

The use of radioactive materials and radiation producing machines is governed by the regulations and requirements issued by the California Department of Public Health (CDPH) and U.S. Nuclear Regulatory Commission (NRC). UC Berkeley is also committed to implement the requirements expressed in its Broad-Scope Radioactive Materials License issued by CDPH, this Radiation Safety Manual (RSM), and any other written commitments made to the CDPH. Any changes to this RSM must be approved by the campus Radiation Safety Committee (RSC) before implementation. Radiation users will receive information on changes that affect them.

This manual details how the appropriate state and federal regulations apply at UC Berkeley. It supersedes and replaces all previous documents and procedures on this topic.

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1 University of California, Berkeley RADIATION SAFETY POLICY

UC Berkeley has an obligation to establish work practices that provide a safe and healthy environment for students, employees, and members of the public who participate in official campus activities. Recognizing potential hazards involved in the use of radioactive materials and ionizing radiation–emitting devices, campus management implements a radiation safety program that keeps exposure to employees, students, and the public "as low as reasonably achievable" (ALARA).

This program is intended (1) to protect personnel from unnecessary radiation exposure; (2) to prevent contamination of our natural resources; and (3) to meet the state and federal regulations governing the possession, use, and disposal of radioisotopes and radiation-producing sources. To this end, this RSM has been prepared by the Radiation Safety Officer (RSO) and reviewed and approved by the RSC and campus executive management.

The RSM describes UC Berkeley policy and practice regarding the use of ionizing radiation and serves as a source of the radiation license requirements. Every "RUA Holder" (RH) and RUA User is provided electronic access to the EH&S website containing the current RSM. The RSC and RSO are specifically responsible to limit, suspend, or revoke an individual's authority to use radioactive material(s) or radiation-producing machines (RPMs) if such use (1) is dangerous to the life and health of individuals, or (2) can place the University in violation of health and safety codes or the UC Berkeley Radioactive Materials License.

UC Berkeley has also established an "Increased Control Plan" (ICP*)* to implement security measures for certain quantities of radioactive materials. Changes and revisions to the ICP will be addressed like revisions to the RSM except only the RSO and RSC Chair will approve the revisions and decide, based on "need to know" who must be trained prior to implementation.

UC Berkeley will establish, implement, and maintain procedures, instructions, and notices necessary to implement the RSM and ICP consistent with criteria approved by the RSC.

2 ORGANIZATION AND RESPONSIBILITY

This section of the RSM describes the organization of the campus radiation safety program and the major responsibilities of each entity involved.

2.1 Chancellor

The Chancellor is responsible for providing and enforcing a radiation safety program that protects user safety and complies with local, state, and federal regulations related to the use of ionizing radiation. The Chancellor delegates responsibility for development, implementation, and enforcement of the radiation safety program to the committees, departments, and individuals described below. The Chancellor retains responsibility for signing the "Statement of Intent" to ensure funds will be available for decommissioning of radioactive material use locations.

2.2 Vice Chancellor for Research (VCR)

The VCR plays a lead role in the UC Berkeley radiation safety program. The VCR appoints members of the RSC and its Chair, reviews reports provided by the RSC, and assists it in accomplishing its goals and mission.

The VCR reviews information on radiation and radiation safety policies, matters related to radiation safety, the status of the program, and problems that may require management's attention when these are brought to his or her attention by the RSC, RSO or Director of EH&S.

2.3 Radiation Safety Committee (RSC)

The RSC is a body of faculty and other radiation experts appointed by the VCR to work with executive management and the Radiation Safety Officer (RSO) to establish policies and procedures for the use of ionizing radiation at UC Berkeley. In addition, the RSC maintains oversight over the program and provides periodic program status reports to the VCR. Oversight activities include the review and approval of radiation-use applications and the review of EH&S radiation safety and radioactive waste related operations.

The RSC ensures that campus executive management is adequately informed of its responsibilities on matters related to radiation safety, the status of the program, and problems that require management attention. Upon request, EH&S can provide a full description of the responsibilities of the RSC and the RSC bylaws.

2.4 Office of Environment, Health & Safety (EH&S)

EH&S implements the campus radiation safety program. EH&S ensures regulatory compliance and safety in the use of radiation and radioactive materials. The program includes audits of all authorizations for the use of radionuclides and Radiation Producing Machines (RPMs). Specific functions of EH&S includes, but is not limited to:

- Monitoring radiation exposure levels
- Investigating incidents involving ionizing radiation

- Consulting on safety matters
- Providing radiation-safety training and services
- Managing radioactive wastes

2.4.1 Executive Director, Environment, Health & Safety

The EH&S Executive Director is responsible for overall management of the campus radiation safety program, in accordance with policy approved by the RSC and with the direction provided by senior campus administrators. The EH&S Executive Director serves on the RSC representing campus executive management.

2.4.2 Radiation Safety Officer (RSO)

The RSO has responsibility for overseeing the radiation safety program and for ensuring that radiation uses conform to UC Berkeley policies and applicable government regulations, including the UC Berkeley Radioactive Materials License. The RSO is a member of the RSC, and is responsible for referring to the committee all matters requiring its review and approval. The RSO reports to the Executive Director of EH&S.

The RSO is empowered to halt any radioactive operations that pose an immediate health and safety danger to the public and/or workers. If the RSC Chair or a second member of the RSC is immediately available, the decision to stop work is coordinated with that person. If not, the RSO has the authority to act alone. The RSO and RSC Chair determine whether and when an emergency meeting of the RSC should be held.

2.5 Department Chairs and Unit Directors

Along with the RSO and RSC, Department Chairs and Unit Directors are responsible for reviewing and approving proposed uses of radioactive materials and RPMs within their jurisdictions. Their approval of the Radiation Use Authorization (RUA) signifies that the department will (1) provide the resources (including facilities and equipment) necessary to control hazards, and (2) comply with applicable campus and governmental standards and regulations.

2.6 RUA Holder

The RUA Holder (RH) is the individual who has applied for and received authorization to use radioactive materials or RPMs. Each RH is responsible for:

- Ensuring that the laboratory (or other work area) is safe for use by personnel, including the radiation user(s);
- Ensuring that anyone permitted to work with or in proximity to sources of radiation or radioactive material has been added to the RUA and has received sufficient training to control and minimize exposure to themselves and others.

- the actions of radiation users listed on their RUA regardless of whether the RH is that person's direct supervisor or not;
- Acquiring both radioactive materials and RPMs only from authorized vendors using authorized

methods and ensuring that purchase requests for radioactive materials do not exceed the RUA inventory limits;

- Reading the RSM and maintaining compliance with the rules and precautions in the RSM and RUA;
- Keeping radiation exposures ALARA; and
- Informing the RSO of any unsafe conditions, radioactive spills or radiation incidents; and
- Posting of RUAs and other required signs/forms.

Proposed RHs must meet specific requirements. RHs must:

- Be employed by UC Berkeley or hold a faculty or research appointment from UC Berkeley;
- Possess a college degree or equivalent experience in the physical or biological sciences or engineering; and
- Have training and/or practical experience in all of the following:
  - The characteristics of ionizing radiation;
  - The manner in which radiation and radioactive materials are quantified and expressed;
  - How radiation dose is quantified and expressed;
  - Use of radiation-detection instrumentation; and
  - Biological hazards of exposures to the types, forms, and amounts of radiation sources to be used.

2.7 User

Users are persons who handle radioactive materials or use radiation-producing machines (RPMs). Every user's name must be listed in the personnel section of the Radiation Use Authorization (RUA). Users are responsible for their own safety and for the safety of those around them; specifically, they must:

- Follow procedures and protocols and know where the RSM can be found online and how to seek assistance from the RST;
- Read the RSM if they are a Lab Contact for the RUA;
- Ensure that training and safety equipment are adequate or check with the RH or RSO if there are any questions;
- Keep exposure to radiation as low as reasonably achievable (ALARA);
- Wear required personal protective equipment (PPE);
- Wear dosimetry and/or participate in the bioassay program if required;
- Inform the RH and/or RSO of any unsafe conditions;

- Keep personal items away from laboratory or use areas;
- Never eat, drink, smoke, or apply cosmetics in the laboratory;
- Place waste materials in appropriate, labeled containers;
- Label work areas, materials, and/or containers as required;
- Maintain appropriate security for radioactive materials and radiation-producing machines;
- If contamination is suspected, check with a suitable survey meter or by means of an "area wipe" and decontaminate if necessary;
- Wash hands and check for contamination before leaving the laboratory, using a suitable survey meter; and
- Immediately report spills, personnel contamination or other radiation safety emergencies to EH&S.

2.8 Minors

Minors between the ages of 14-18 years old who wish to work with radioactivity or radiation must be students in an enrolled class involving laboratories, or part of an approved or supervised tour, or have written consent of their parent or guardians and be under the direct supervision of a qualified adult. These restrictions apply to minors who are volunteers or summer interns. RHs must apply to the RSO for exceptions and exceptions must be documented in writing. Minors under the age of 14, including children of laboratory personnel, are not permitted in posted radiation use locations, except when participating in an approved and supervised tour. The RUA Holder must approve of a tour in their radiation use locations.

2.9 Ancillary Personnel

Ancillary personnel include all workers (maintenance, researchers, interns, students or administrative) who are assigned to perform work in areas listed on an RUA, but who are not working directly with radioactive materials or RPMs. The RH is responsible for ensuring that ancillary personnel receive radiation safety training commensurate with the potential radiological health protection risks in the controlled area. Ancillary Worker training is available on the EH&S radiation safety website for this purpose and this training must be documented.

3 LICENSING REQUIREMENTS

3.1 UC Berkeley Radioactive Materials License

The Radiation Safety Program at UC Berkeley is operated in compliance with federal and state regulations. The CDPH granted UC Berkeley a facility-specific license to address the varied uses of radioactive materials and radiation on campus. This "Broad-Scope Type A" license provides UC Berkeley broad flexibility in meeting regulatory requirements, and identifies specific requirements for the use of radioactive materials at UC Berkeley.

When requesting approval to use radioactive materials or RPMs, the applicant needs to understand the requirements set by UC Berkeley, and that the license itself carries special requirements. The UC Berkeley policies on radiation safety are outlined in this manual and are available electronically on the EH&S website. The RSO serves as the lead for the program documents, and for understanding and interpreting regulatory and campus requirements.

State regulations that apply to radioactive materials are found in Title 17 of the California Code of Regulations (CCR). For most applications in California, the CDPH develops and enforces regulations, licenses uses, and performs inspections and investigations. In some cases, the NRC regulations contained in Chapter 10 apply directly to UC Berkeley.

3.2 Exemptions to Regulations

Some uses of radiation and radioactive materials are not regulated under the UC Berkeley Radioactive Materials license. Exemptions include specific consumer products containing radioactive material (e.g., un-modified products such as some balances, smoke detectors listed in 17 CCR 30180(b). Radiation safety staff should be consulted for requirements on proper use and disposal of these items.

3.3 Radiation Use Authorization (RUA)

Specific uses of radiation and radioactive material at UC Berkeley must be pre-authorized in writing. The written authorization is referred to as an RUA and is fundamental to the campus radiation safety program. An approved RUA is required before taking possession of (purchasing, borrowing, constructing, etc.) most sources of ionizing radiation. Application for an RUA is made using forms available on the EH&S website.

The radiation safety staff evaluates the radiation safety aspects of the proposed use. If additional information is required, the RSO may need to meet with the applicant to discuss the proposed use.

RUA approval for any proposed use of radioactive materials and/or RPMs is based on the use, the risk/hazard evaluation, the adequacy of health and safety measures to be employed, and the evaluation of the RSO.

3.3.1 Application for Material or Machine Use

For an initial application, complete and submit the following forms, available on the EH&S radiation safety website:

- Radiation Use Authorization Application
- Standard Operating Procedures for each type of experiment
- Radiation User Information Record(s) for each radiation worker

3.3.2 Instructional Use

An RUA is required for any use of radiation or radiation sources in academic course work or laboratories. Such RUAs are issued in the name of the instructor.

3.3.3 Use of Radiation in Animals

In addition to the process described above, if research will involve the use of animals that (1) fall under the jurisdiction of the Animal Care and Use Committee (ACUC), and (2) will be exposed to radiation or given radioactive materials, then both an RUA and approval by the ACUC are required before exposure to radioactive materials or radiation may occur.

3.3.4 Use of Radiation in Human Research

Research involving radioactive material or radiation from radioactive materials in or on humans is not authorized by the UC Berkeley Radioactive Materials License and is not permitted. Requests to perform research using radioactive material can be coordinated with another campus licensed to perform that type of research.

3.3.5 Application for Use of Radioactive Materials or RPMs Offsite and/or in the Field

Requests to use radioactive materials in the environment (field applications of dispersible radionuclides) at use locations specified in the Radioactive Material License (License Condition 10) should be made 90 days in advance of the planned use to allow for review of the proposed work by the Radiation Safety Committee and for submittal to the state for final approval.

In cases where an RH wishes to use radiation or radioactive material at a location which has **not** been listed on the Radioactive Materials License, the RSO will have to apply for a license amendment and approval may require multiple months.

3.4 Review of RUA Applications

After the application for a RUA is submitted, the RSO reviews the materials and generates an RUA. Based on the review, the RSO determines the precautions necessary for use and the level of review required. In the case of Class 1 RUAs, the RSO may approve the application. In the case of Class 2 RUAs, the RSO and the Chair of the RSC is required for approval. In the case of Class 3 RUAs, the RSO and a quorum of the RSC is required to approve the application. Details of the review and approval process are found in Appendix 1, "Radiation Use Authorization (RUA) Application Process."

3.5 RUA Amendments and Revisions

Any change to or modification of an existing RUA must be reviewed and approved before implementation. Revisions and amendments to approved RUAs may be requested at any time by submitting your request electronically using a RUA Change Request form from the website or by contacting the RSO or an EH&S RST staff member.

3.5.1 Amendments

Amendments involve significant changes to the form, quantity, protocol, standard operating procedures or use of radioactive materials such that the RUA Class increases or a substantive change to the radiation safety precautions is necessary. Amendments may require approval of the RSC or the RSC Chair. The RSO determines the level of review required.

3.5.2 Revisions

Revision to RUA can be made at the request of the RH or radiation safety staff and they only require approval by the RSO or a designee. Revisions do not involve changes to the RUA Class. Revisions typically involve addition or deletion of personnel, minor adjustments to an authorized limit for a radioisotope, changes to survey frequency, or other changes of minor safety significance.

3.5.3 RUA Renewal

Annually, an RST member performs a complete review with the RH and Lab Contact of the RUA to determine if any changes are needed. The RUA is amended if needed and renewed for another year if the project plans to continue. If a project is at completion, a termination survey will be scheduled.

A RUA may be placed "On Hold" at the request of the RH if no use is planned for at least 6 months. The frequency of EH&S RST oversight surveys may be reduced to a minimum of semi-annual visits. However, the RST will continue to periodically audit on-hold RUAs to confirm that radioactive materials and RPMs are not being received, used, moved or disposed. These surveys may be conducted by telephone, email or unannounced inspection of the storage or authorized use locations.

3.6 Registration of Radiation-Producing Machines (RPMs)

The UC Berkeley campus uses a wide variety of ionizing radiation–producing machines (RPMs) such as:

- Electron microscopes
- Medical machines
- Cabinet X-ray machines
- X-ray diffraction and fluorescence analysis machines miscellaneous machines including accelerators.

All machines that produce ionizing radiation must be registered with the CDPH within 30 days of arrival on campus by the RSO. RHs are responsible for notifying the RSO so that the required registration can be completed. An approved RUA for each RPM is also required.

The RSO must also notify CDPH within sixty days prior to the acquisition, construction or reconstruction of a room to house:

- Any RPM capable of operating at a potential in excess of 500kVp
- Any RPM that operates at a potential in less than 500kVp, but that for other reasons presents a similar radiological hazard

3.7 EH&S Radiation Safety Surveys

3.7.1 Safety Survey Frequency and Content

The RST perform periodic surveys of areas in which radioactive materials or RPMs are used. The frequency of the surveys is based on a number of factors, such as potential risk and past RUA compliance. The typical frequency of surveys is within the following time ranges:

Class 1- Semiannually to Annually
Class 2- Quarterly to Semi-Annually
Class 3- Monthly to Quarterly

All RPMs will at minimum be surveyed annually and all sealed sources will be surveyed at minimum semi-annually. Survey frequencies can be increased or decreased based on compliance history. The CDPH expects that no less than 50 percent of the surveys performed by EH&S staff will be performed "unannounced." More frequent surveys may be mandated by the Radiation Safety Committee based on the compliance record.

These surveys are performed to determine if operations are being conducted properly and safely. Specifically, EH&S surveys will include checking the following:

- Are the form and quantity of radioactive material present consistent with the limits on the RUA?
- Are radionuclides used in accordance with the conditions of the RUA and RSM?
- Are only authorized individuals granted access to and use of radioactive material and RPMs?
- Is eating and drinking properly prohibited from posted RUA locations that authorize possession of radioactive material?
- Are laboratory procedures available and followed?
- Are required safety notifications posted and adequate?
- Is proper PPE being used?
- Are contamination/area surveys performed as scheduled, and are they appropriate?
- Are all radioactive materials and RPMs controlled and secured?
- Is radioactive waste being properly managed?

If problems (such as contamination and/or external radiation areas) are found, the RH will be asked to take corrective action. A copy of the survey report is kept on file in EH&S and a copy is sent to the RH.

3.7.2 Consequences of Noncompliance

When problems are identified, EH&S staff members prepare a survey report detailing the issue(s) and the needed corrective action(s). The RSO reviews all reports of significant radiation safety problems, determines what action(s) must be taken, and sets the date by which corrective action must be completed. The report is sent to the RH and a copy is filed with the EH&S records for the laboratory.

In the event of any single serious violation, discovery of unsafe conditions, or chronic non-compliance indicative of a programmatic breakdown, the RSO brings the matter to the attention of the RH as soon as possible. The RH will be requested to respond in writing to the RSO by acknowledging or denying the unacceptable situation, describing the corrective actions taken or planned, and when corrective actions will be complete. The RSO may take additional action approved by the RSC, or may refer the matter to the RSC or its Chair.

Serious or chronic noncompliance can result in review by the RSC and may lead to restrictions, more frequent EH&S surveys, additional training, or, in severe cases, cancellation of the RUA.

In the event that an RH (or person working under the supervision of the RH) is found to be willfully and/or negligently violating federal, state, or University requirements governing the use of radioactive material and/or RPMs, any or all RUAs under that RH may be suspended or revoked (with RSC concurrence) and radioactive materials may be confiscated.

If at any time the RSO is not satisfied with a project's safety and health practices, the project may be halted until corrections have been made. The RSO's action(s) may be appealed to the RSC.

3.8 RUA Termination Procedures

RUA Holders who are approaching the termination of a project that uses radioactive materials or radiation producing devices should notify the EH&S RST to schedule the termination survey of the use areas. The termination survey will include an accounting of radionuclide inventory and satisfaction of requirements for decontamination. The area cannot be released for other uses until this termination process has been completed.

Upon termination of the RUA, all remaining radioactive materials must be transferred to another active RUA project authorized for the same type and quantities of radionuclides, or to EH&S for proper disposal as radioactive waste. In the case of RPM's, the RUA is not terminated until the machine has been transferred or disposed of. The RST must notify the state within 30 days of transfer or disposal of RPM's.

3.8.1 Termination of Use of Facilities

Once an area has been under an RUA, it cannot be transferred to unrestricted use for other purposes until the RST has released it. If necessary, areas will need to be decontaminated to a level that satisfies regulatory requirements. Decontamination is the responsibility of the RH, but the RST can provide technical assistance and will perform independent surveys to confirm the effectiveness of the decontamination effort.

All remodeling to areas where radioactive materials had been used or stored must be coordinated with the EH&S RST.

Unrestricted release of buildings or of locations specified in the license require prior approval of CDPH. The RH must notify EH&S RST well in advance of plans to terminate use of radioactive materials in a campus building or at an offsite use location.

3.9 Medical Monitoring and Examination Requirements

As a condition of use of radioactive materials and RPMs, the user agrees to personal monitoring required by regulation to determine his/her dose. This may include wearing dosimeters, using air sampling devices, and/or participating in a bioassay program as specified on the RUA. It may also include a medical examination and medical monitoring.

4 RADIATION EXPOSURE POLICY

4.1 ALARA (As Low As Reasonably Achievable) Policy

UC Berkeley has a policy of preventing unnecessary radiation exposures to persons and the environment, and to keep any exposures as low as reasonably achievable (ALARA). ALARA attempts to maintain exposures to radiation at below the dose limits, consistent with the purpose for which the exposure is generated, but also taking into consideration the state of technology, the cost of the improvements needed to reduce the radiation exposure, and the benefits to public health and safety.

4.2 Occupational Doses

While the goal for radiation exposure is ALARA, in no case are occupational doses for radiation users permitted to exceed the CDPH limits specified in Table 1, below.

Table 1. Occupational Dose Limits (external and internal sources added together) in millirems per year

Category of Dose Equivalent	Regulatory NRC/CDPH Limit	UC Berkeley Administrative Guideline[1]
Whole body	5,000 mrem/yr	500 mrem/yr
(Eye) Lens	15,000 mrem/yr	1,500 mrem/yr
Skin or extremities (hands and forearms, feet and ankles)	50,000 mrem/yr	5,000 mrem/yr
Organs	50,000 mrem/yr	5,000 mrem/yr
Minors (<18 years of age)	500 mrem/yr	50 mrem/yr

[1] Administrative guidelines are dose equivalent recommendations adopted by the Radiation Safety Committee (RSC) for all UC Berkeley personnel. If these guidelines are exceeded, a review by the Radiation Safety staff is required to determine if additional safety measures are required. +The administrative guidelines are not intended to be absolute limits, but to provide guidelines for keeping exposures ALARA.

4.3 Public (Non-Occupational) Doses

Radiation exposure to members of the general public are considered “non-occupational” exposures. All activities must be done in a manner that limits the exposure of non-radiation users to the regulatory limits for members of the public specified in Table 2, below.

TABLE 2. PUBLIC (NON-OCCUPATIONAL) DOSE LIMITS (EXTERNAL AND INTERNAL SOURCES ADDED TOGETHER)

Category of Dose Equivalent	Regulatory NRC/CDPH Limit
Annual limit/guideline for dose to any individual member of the public	100 mrem
Limit/guideline for dose to any individual member of the public in a single hour	2 mrem

4.4 Prenatal Radiation Exposure Policy

The NRC and the State of California regulate permissible radiation-exposure doses to an embryo or fetus over the course of the pregnancy of a worker receiving occupational radiation doses.

4.4.1 Declared Pregnant Worker

Special dose limits, risk options, and monitoring requirements exist for workers who declare their pregnancies. If the pregnant worker chooses to declare her pregnancy, she must provide EH&S with a written statement. A form which may be used for this purpose (or as a guideline for the information that should be provided) is available at the EH&S radiation safety website.

The decision to declare pregnancy is completely voluntary on the part of the worker. However, a woman who chooses not to declare her pregnancy is neither subject to, nor protected by the regulatory provisions for women who have declared their pregnancies. The dose limit to the embryo or fetus during the entire pregnancy of a declared pregnant worker is not to exceed 500 mrem. A woman who has declared her pregnancy may decide what level of risk to accept; she may choose a level of risk lower than the regulatory limit.

The RSO's review of the declared pregnant woman's potential exposures may result in work modifications and/or the assignment of special dosimetry.

4.4.2 Resources for Pregnant Workers

The NRC's Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure," as well as forms that may be used to declare pregnancy or to withdraw a previous declaration of pregnancy may be found on the EH&S website. Additionally, the campus RSO is available to answer any questions users may have. Upon request, all inquiries and information are kept strictly confidential.

4.5 External Radiation Dose

4.5.1 Requirements

Personnel exposure monitoring must be provided if a person is likely to receive a radiation doses in excess of 10 percent of CDPH limits. Dosimetry is also required for individuals entering an area of "high" radiation (>100 mrem/hour).

To determine if dosimetry is required or recommended, the RSO reviews the specific use(s) described on the RUA before work begins. Based on the RSO's review, dosimetry requirements are determined and are indicated on the RUA. There are generally two types of external dosimetry:

Whole-body monitoring of external radiation exposure (usually by thermoluminescent dosimeter [TLD] or an equivalent badge)

Extremity monitoring (usually by ring dosimeter)

Dosimetry will be provided and processed only by vendors accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

4.5.2 Supplementary Dosimeters

In special cases specified in the RUA, supplementary dosimetry may be required and will be provided by the RST Dosimetry Coordinator.

4.5.3 Obtaining Initial Dosimeters or Temporary Replacement Dosimeters

You may contact the RST Dosimetry Coordinator to arrange a time when you can pick up the needed dosimeter(s). The Dosimetry Coordinator will provide a form to be submitted at the time of pick-up. The Dosimetry Coordinator will request an estimate of the dose received during the current year from prior work with radioactive materials or radiation and will attempt to obtain records of your cumulative occupational radiation dose.

4.5.4 Proper Use of Dosimeters

All users of external dosimeters should follow these requirements:

- Wear the assigned dosimeter(s) whenever working with radiation or radioactive material at the locations specified on the RUA.
- Wear monitors correctly: Whole-body badges are normally worn on the belt or at chest level. It is important that the badge be worn with the identification label facing out (rather than facing the body). The badge should not be covered while it is being worn (e.g., it should be worn on the outside of user lab coats). Extremity monitors (rings) are usually worn on a finger of the hand most used, with the detector facing the radiation source.
- Store dosimeters away from sources of radiation and environmental extremes (e.g., extreme moisture or extreme heat).
- Exchange and return dosimeters as soon as possible after the replacements arrive. If a replacement dosimeter fails to reach you on schedule, inform EH&S, but keep using the original dosimeter until you have obtained a replacement.

- Contact EH&S promptly if you lose a dosimeter. EH&S will provide a replacement dosimeter and work with you to assess and document the radiation dose for the period covered by the lost dosimeter.
- Use only the dosimetry that was provided to you. Never borrow a dosimeter assigned to anyone else and never loan anyone a dosimeter.
- Never intentionally expose your dosimeter to radiation sources.
- Promptly notify EH&S if you accidentally expose your dosimeter.

  Please notify EH&S about any medical procedure (e.g. diagnostic or therapeutic administration of radionuclides) that could cause a dose to your dosimeter(s).

4.6 Internal Radiation Dose

Internal radiation dose occurs if radioactive material is inhaled, ingested, injected, absorbed through wounds, or absorbed through the skin. Use of radioactive materials creates risks of a material being spilled on the skin or taken into the body. Protective clothing and other measures must be used to prevent or reduce internal radiation dose.

The RSO reviews each RUA before work begins. One aspect of the RSO's review is to determine the potential for internal exposure. The RSO determines what, if any, controls (such as use of a fume hood) may be required. The RSO determines the need for bioassays and notes the requirement on the RUA.

In some cases, individuals receive special monitoring ("bioassay") to determine if there has been any internal dose. Bioassay is the analysis of radioactive materials in the body. Measurements are taken by a variety of methods, including directly counting the body or body parts (in vivo) or analyzing excreta (in vitro). Both methods measure the amount of radioactive materials in the body. In general, two types of routine bioassays are performed at UC Berkeley: (1) thyroid counts, for some users of significant quantities of radioiodine, and (2) urine assays, for other radionuclides. Other methods may be used when appropriate.

If an individual's bioassay detects the presence of radioactive material (above what is naturally occurring), the RSO will assess the dose and suggest methods to reduce future uptakes.

4.7 Review of Doses

All internal/external exposure monitoring results are reviewed by the RSO to ensure that regulatory and campus limits are not exceeded and that exposures are consistent with ALARA. Any occupational exposures greater than the administrative guidelines of 10% of the legal limits requires investigation for accuracy and cause. These values are:

- Whole-body doses ≥167 mrem in a dosimetry reporting period (typically a period of 4 months), and
- Extremity doses ≥1667 mrem in a reporting period. If the reading is determined to be accurate, the review helps determine the cause and address the means to reduce future exposures.

4.7.1 Routine ALARA Exposure Reviews

The RST periodically review exposure results and RUA use conditions, and may suggest actions to keep exposures ALARA. Exposures measuring above applicable UC Berkeley administrative guidelines are investigated further.

4.7.2 Summary of Dose and Special ALARA Exposure Investigations

An individual's internal and external doses are added together and recorded as the total effective dose equivalent. If any individual's combined external and internal dose reaches or exceeds applicable UC Berkeley administrative guidelines, the RSO conducts a special ALARA exposure investigation.

4.7.3 CDPH Limits

In the case of known or suspected overexposures (exposures exceeding CDPH limits), the RSO notifies the CDPH. The RSO/RSC may recommend personnel undergo medical evaluation and/or treatment by a qualified physician.

4.8 Review and Distribution of Monitoring Results

At any time, personnel may request a summary report of doses received while working at UC Berkeley. To protect confidentiality, the request must be written and signed by the person asking for the report, and submitted to the RST for action. The EH&S RST provides annual reports to all individuals who received a measureable occupational dose and who are either on campus or who have left forwarding addresses.

5 AUTHORIZATION AND TRAINING OF PERSONNEL

5.1 Authorization

Individuals **must** be listed as authorized personnel on the RUA before beginning to work with radioactive materials or RPMs. The RH will decide the level of supervision necessary for each of his/her authorized users and retains responsibility for all RUA users listed on his/her RUA.

Unescorted access to certain radioactive materials requires fingerprinting, criminal history record check and background investigation in accordance with the UC Berkeley Increased Controls Plan and Criminal Background Check Policy.

5.2 Training

Radiation workers must be trained in the hazards they may encounter on the job, in the methods of protecting themselves and how to minimize their exposures. It is the joint responsibility of the RSO and the RH to ensure that every user listed on the RUA has completed the required radiation-safety training.

5.2.1 Required RH and User Initial Training

All personnel (including prospective RHs) who will be working with ionizing radiation must successfully complete radiation safety training before being added to the RUA as an authorized user. The form that prospective RHs and users must submit in order to be added on an RUA may be obtained at the EH&S radiation safety website.

EH&S RST will provide general radiation safety training courses appropriate for the majority of individuals who intend to use sealed or unsealed radioactive materials or RPMs. Prospective users will be required to take the applicable radiation safety training online or in-person or a combination of the both formats. The initial training will cover:

- How to post areas where radioactive materials are stored or used or where radiation exposures will occur.
- How and where to record the receipt, transfer, and disposal of radioactive material, including sealed sources.
- How to properly store and prepare radioactive waste for collection.
- How to comply with bioassay procedures.
- The risk associated with radiation exposure.
- How to conduct and file surveys of workplaces where ionizing radiation work is performed.
- How to keep work areas free of contamination and to properly prepare work areas before using radioactive materials.
- How to minimize the storage of radioactive materials within the laboratory/work area.

- How to formally terminate use of ionizing radiation.
- How to locate a copy of the campus RSM.
- How to use laboratory equipment, including (1) personnel monitoring devices (dosimeters), if assigned; (2) survey meters; (3) personal protective equipment (PPE); and (4) engineering controls as specified in the RSM or the RUA.

  How to notify EH&S Radiation Safety immediately in the case of (1) personnel contamination, (2) spills, or (3) potential excessive radiation exposure accidents, or after any unusual event resulting in contamination of work areas or release of a radionuclide or radiation beyond the confines of the authorized work areas.

For class work and specialized instruction, the RH or EH&S may provide training materials appropriate to the extent of radiological hazards present during the instructional experience as required reading. The RSO must approve the training materials. The training must be documented and the RH is responsible to insure only those individual completing the training required by EH&S will be allowed to participate in the class or specific training exercise. Records of this training must be maintained by the RH and copies provided to EH&S, when requested since these individuals may not be listed on the RUA.

5.2.2 Requests for Temporary Permission for Radiation Source Use in Advance of Completing Usual Initial Training

In rare situations, the RSO may grant permission for an individual to work with radioactive materials (or radiation producing machines) without first completing the standard initial training described in the previous section if they are confident that the individual is knowledgeable in the work to be performed and the safety requirements of UC Berkeley.

5.2.3 Required User Training Following Changes in RUA Procedures

The RH is responsible for providing users listed on the RUA with appropriate re-training whenever there is a change in the radiation use, in individual duties, or in the work environment. The frequency of such retraining should be sufficient to ensure that all staff members are adequately trained.

5.2.4 Required RH and User Refresher Training

All active RHs and users must complete radiation safety refresher training biennially. EH&S RST will provide the refresher training course that will review radiation safety requirements, address new issues and identify ways to reduce dose and improve performance. If more frequent retraining information needs to be communicated, email notification of important lessons learned or updated information will be sent out to RHs and users. The Radiation Safety Committee may also mandate more frequent retraining based on compliance issues.

With the exception of very low risk activities like use of electron microscopes, exempt quantities and some generally licensed materials, failing to complete biennial radiation safety refresher training as scheduled, will be cause for removal from the RUA. These individuals will be notified of their delinquency and

removed from the RUA within a set period. The RH will be informed and requested to restrict the person's access to radioactive materials and/or RPMs.

The RSC may terminate an RUA or request a Department Chair to replace an RH, if that RUA Holder fails to complete biennially retraining as required.

5.2.5 Required Training for Ancillary Personnel

Each RH is responsible to provide a safety briefing to all students, vendors, visitors, and others who will be present in any of the authorized use locations. This briefing must summarize potential hazards in the area, the meaning of posting, labeling, and access control measures and of the actions individuals should take in response to radiological alarms or direction from authorized users.

The RH may provide ancillary personnel with a copy of the "Radiation Safety Procedures for Non-Users" along with instructions specific to the RUA to meet this requirement.

The RH must maintain records of the dates and names of individuals involved in such training.

6 PROCEDURES FOR WORK WITH RADIOACTIVE MATERIALS

Everyone who uses radioactive materials is responsible for ensuring that personnel radiation exposures are kept **a**s **l**ow **a**s **r**easonably **a**chievable (ALARA). This section includes standard laboratory best practices and procedures to accomplish this. The Radiation Use Authorization (RUA) may prescribe additional specific precautions and conditions.

6.1 Procurement Procedures

Obtain prior approval using the Radiation Safety Information System (RSIS) before procuring radioactive materials, whether procurement is by purchase, transfer, loan, or gift. Each order must be within the limits listed on the RUA or the RSIS will not generate an authorization number. EH&S RST staff will verify the authorization number is present with each purchase when it arrives, as part of their receipt survey. The order must include the authorization number so that the delivery is not delayed.

6.2 Transferring Radioactive Material

Transfers of radioactive materials may be proposed between RUAs using RSIS. All proposed transfers that fall within RUA limits will be instantly approved by RSIS.

Off-campus transfers are governed by federal and state regulations; such transfers must be made through EH&S RST. You may initiate a transfer of radioactive materials to another institution through RSIS.

6.3 Receiving Radioactive Material

All radionuclide shipments are delivered by the carrier to the EH&S- Hazardous Material Facility at 1 Frank Schlessinger Way, Berkeley, CA 94720. EH&S RST inspects each package for the following:

- Conformance with the RUA limits, previous deliveries, and lab inventory
- Damage to or contamination of the contents or containers
- Conformance with Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC) regulations

If the shipment passes inspection, it is delivered to the RH's laboratory or storeroom as prearranged. The transfer is formal and the recipient signs for the materials. EH&S RST maintains records of radionuclide receipts.

Prior arrangements must be made for shipments that will not conform to the procedures described above such as the acquisition of a RPM at a specific laboratory or the direct delivery of equipment that contains radioactive sources (e.g., liquid scintillation counters, gas chromatographs, etc.).

6.4 Security of Radioactive Material

The RH is responsible for the ongoing custody and security of any radioactive material under the RUA. Any loss or potential loss of radioactive material must be reported to EH&S (510) 642-3073 as soon as possible after the loss is suspected.

Rooms containing radioactive material must be locked or under the control of RUA personnel such that measures can be effectively taken to prevent the unauthorized use or removal of the material. If non-RUA authorized users are permitted to be in the room where the radioactive materials are stored, then the radioactive material must be either under constant surveillance by RUA personnel or locked such that it cannot be used or removed by an unauthorized individual.

6.5 Restricted and Controlled Areas

A *controlled area* is one to which access can be limited to authorized personnel in order to prevent undue risk from exposure to radiation or radioactive materials. A *restricted area* is one to which access is always limited to authorized personnel.

All entrances to restricted areas must remain closed and locked when not under constant surveillance by an individual trained to control the radiation hazard. Members of the public are not allowed in restricted areas without the escort of laboratory staff or EH&S staff. Details may be found in the UC Berkeley policy "Access to Laboratories Containing Hazards" available on the UC Berkeley website. All visitors must be given a safety briefing, summarizing potential hazards in the area, prior to entering a restricted area. This may be done most conveniently with a safety briefing sheet that can be handed to visitors to review and discuss with the RH or authorized user.

6.6 Inventory Control and Possession Limit

RHs must keep records and inventories of all radioactive materials under their control. Each record must include the radioisotope, quantity (in millicuries or in grams for source material or SNM), activity, date, and storage location. The on-line inventory application, RSIS, must be used for this purpose.

The inventory records should also include sufficient information to help locate the materials. This may include the location of the original stock container and other secondary vials and/or material that is in waste.

The RH must ensure periodic audits are conducted to visually verify the locations of all sealed and unsealed radioactive materials. This is normally done at the time of routine RST surveys. In all cases, a record of the

inventory audit is made and preserved in RSIS. Missing radioactive material must immediately be reported to the RST. The RSO will inform CDPH, as required.

If source, special nuclear material, or nationally tracked sources are used, special inventory, physical protection, and reporting requirements apply. Special nuclear material must be inventoried in January and July of each year in accordance with EH&S RST procedures. Any apparent discrepancy of more than one gram must be immediately reported to the RSO. Source material must be inventoried each September and discrepancies of more than 500 grams must be immediately reported to the RSO. Transfer or disposal of special nuclear material, source material and nationally tracked sources must be coordinated with the RSO due to special security and federal reporting requirements.

6.7 Posting Requirements for Radiation Laboratories

Approved radiation-warning signs are required where the potential for exposure to radiation exists.

At minimum, the RH must ensure the following are properly posted:

- **Caution Trefoil Signs:** All entrances must be posted with a sign bearing the radiation caution symbol and the words, **"CAUTION: RADIOACTIVE MATERIAL(S)."** for radioactive materials laboratories.
- **Current RUA:** The currently approved version of the RUA must be posted in the laboratory.
- A copy of the **Radionuclide Emergency Procedures** provided by EH&S RST.
- EH&S RST may also post **"CAUTION: RADIATION AREA"** or **"CAUTION: HIGH RADIATION AREA"** signs as appropriate.

6.8 Labeling Requirements

6.8.1 Labeling Containers

- Vials and containers must be labeled to indicate that they contain radioactive material. (planchets and vials containing counting samples are exempt from this requirement.)
- When double containers are used, both inner and outer containers must be labeled (unless the inner label is visible from the exterior).
- Labeling requirements also apply to radioactive waste. The radionuclide and the approximate amount of radioactivity must also be posted on the radioactive waste container.

6.8.2 Labeling Equipment

Equipment-labeling requirements depend on the relative permanence of the operation. If an apparatus emitting more than twice the background amounts of radiation will be turned on or in use for eight hours or more (or overnight), it must be labeled.

6.8.3 Labeling Work Areas

All work areas used in radionuclide procedures (including tabletops, equipment, and storage areas such as refrigerators) must be labeled. "Radioactive Material" caution tape should be used to clearly delineate the area(s) you plan to work in. At least one bench or area label should identify the radioisotope(s) being used in that area, and must contain a radiation symbol (trefoil) with text that reads, "Caution: Radioactive Material."

6.8.4 Labeling Sealed Sources

Unless impractical, label the sealed source, its shield, or the apparatus in which the source is mounted with a permanent radiation warning sign. Unless otherwise indicated, the sealed source should also be labeled with the radioisotope, initial activity, and the date of initial activity.

6.8.5 Requirement for Removal of Labeling and Posting

Prior to sending equipment previously used in radioactive materials research (e.g., centrifuges, refrigerators, etc.) for repair or disposal, and prior to discarding packaging materials from radioactive shipments, users must:

- Survey them appropriately and determine that they are free of contamination. Maintain records of any surveys performed to release equipment for repair or disposal. Alert the RST of your plans to return this equipment so they can confirm that the object is free of contamination.
- Remove or deface all radiation labels and posting.

6.9 Radiation Exposure and Contamination Control in the Laboratory

The level of radiation control assigned to an RUA is determined by the RSO and reflects at least the following: (1) the internal radiotoxicity of the materials authorized under the RUA, (2) the external radiation

exposure hazards, (3) the complexity of procedures, and (4) the physical and chemical characteristics of the material used. Specific controls are noted on each RUA.

6.9.1 Internal Contamination

Internally deposited radionuclides (internal contamination) are a matter of concern. Internal uptake is best avoided by using proper containment techniques, minimizing surface contamination, using appropriate personal protective equipment (PPE), and using proper engineering controls.

To prevent internal contamination, the following precautions must be taken when working with unsealed radioactive materials.

- Do not eat, drink, smoke, or apply cosmetics in restricted areas where unsealed radioactive materials are stored or used.
- Do not pipette radioactive materials by mouth; use mechanical methods.
- Use a fume hood for handling any radioactive material that may become airborne.
- Wear appropriate personal protective equipment (PPE), (e.g., safety glasses, face shield, gloves, Lab coats, closed-toed shoes, pants.)
- Perform contamination surveys during the course of the experiment and immediately upon completion.

6.9.2 Food and Drink Policy in Laboratories that Use Radioactive Materials

Consumption or storage of food and drink is not allowed in radiation use laboratories. Exceptions may be granted on a case by case basis by the campus Radiation Safety Committee (RSC) if the use is consistent with policy on other laboratory hazards.

6.10 Best Practice: Overview: General Radiation-Control Techniques

The following are general procedures for radiation control in a radionuclide laboratory:

- Do not bring personal belongings, other than those required for work, into the laboratory.
- Separate radiation work and storage areas from general personnel spaces. Store your lab coat away from your personal clothing.
- Do not eat, drink, smoke, or apply cosmetics in the laboratory where unsealed radioactive materials are present unless a designated “Clean Area” has been established.
- Cover work areas with absorbent paper to protect against spills. Use a spill tray when working with large volumes of liquids.
- Use appropriate shielding.
- Put waste materials in appropriate containers and keep liquid waste in secondary containment.

- Maintain good housekeeping in the laboratory.
- Restrict public access and properly control access by minors.
- Use appropriate signs.
- Wear impervious gloves and use tongs.
- Use mechanical (remote) pipetting techniques.
- Do not work with radioactive materials if you have an open skin wound.
- Wear appropriate PPE over street clothes (e.g., fire resistant clothing if working with flammable materials).
- Clearly label contaminated glassware or equipment until it has been decontaminated.
- Use fume hoods when working with volatile materials.
- Label work areas, materials, and/or containers as required.
- Survey radiation-use areas with an appropriate survey technique (e.g., survey meter or area "wipe test"), performed and documented at the frequency specified on the RUA.
- Use radiation-detection equipment during manipulations of unsealed radionuclides to detect and prevent the spread of contamination.
- Check gloves, forearms and other PPE for contamination frequently.
- If contamination is suspected in the course of work, monitor the area using a suitable survey meter or area wipe, and decontaminate if necessary.
- Wash your hands and check them with a suitable survey meter before leaving the laboratory.

6.11 Additional Requirements for "High" and "Very High" Radiotoxicity Nuclides

If you will be working with radionuclides with high or very high radiotoxicity, as defined in Appendix 1-Table 5, your RUA will note that fact and additional precautions will be required. The following should be considered:

- Pre-plan the operation in detail and consult with the RST.
- Decide on actions required in case of emergencies.
- Perform dry runs without any radioactivity if the procedure is new or unfamiliar to you.
- Develop the skills necessary to satisfy the special needs of the project.
- Inform personnel working with radioactive materials (and those who could be affected by incidental exposure or accidents) of safety practices and emergency procedures.
- Have all project participants wear personnel monitors if dosimetry is specified on the RUA.
- Frequent monitoring of all areas and operations.

6.12 Laboratory Self-Surveys/Checks

Contamination is most easily detected by conducting routine monitoring surveys to detect excessive radiation and/or contamination levels. This alerts laboratory personnel to potential hazards. Survey requirements are specified on the RUA. Table 3 below lists methods and instruments recommended for detection or measurement of radioactive materials.

Table 3. Recommended Radiation Detection Instruments

Radiation Type	Energy	Isotope examples	Detector
Alpha	All	Am-241, Cf-252, special nuclear material	ZnS scintillation Proportional counter Wipe—LSC
Beta	< 60 KeV	H-3	Wipe—LSC
	≥ 60 KeV	C-14, S-35, P-33, P-32, source material	Pancake GM Proportional counter Wipe—LSC
Gamma or x-ray	< 200 KeV	Cr-51, I-125 Am-241	Thin Sodium Iodide scintillation Wipe—LSC Energy compensated GM Ion Chamber
	≥ 200 KeV	Na-22, I-131, Cr-51 Cs-137, Ra-226	Thick Sodium Iodide scintillation Wipe—LSC Calibrated GM Ion chamber Solid state detectors
Neutron	all	PuBe, AmBe accelerators	Proportional counter Neuron detectors

6.13 Survey Frequency

Routine monitoring should occur during and following all active work with dispersible sources of radioactive materials. Additionally self-surveys shall be ***documented at minimum once a month*** or more frequent as warranted by the nature of the work. If more frequent documented self-surveys are required, it will be noted in your RUA.

6.13.1 Survey records

Keep permanent written records of all survey results, including negative results.

For radioactive materials RUAs, the surveys must include:

- Location, date, and radiation detection instruments used (model and serial number
- Name of person conducting the survey.
- Map of the surveyed area, with identifying relevant features such as active use, storage and waste areas.
- Measured exposure rates and/or contamination levels, keyed to location on a map of the area.
- Corrective action taken, if contamination or excessive exposure rates were found, and the reduced levels after corrective action.

Where required, RHs must maintain permanent written records of such surveys and tests.

6.14 Decontamination Requirements

Laboratory surfaces, equipment, and clothing may become contaminated in spite of proper precautions. Such contamination does not necessarily present a serious hazard. This is especially true if it is (1) detected promptly, (2) not allowed to spread or be ingested, and (3) removed, to prevent cross-contamination to other surfaces and objects.

The RH or designee is responsible for seeing that decontamination is carried out properly and that personnel are instructed in decontamination procedures. EH&S RST provides assistance or supervision in cases of personal contamination or significant levels of contamination. When decontaminating:

- Wear appropriate protective clothing (gloves, lab coats, etc.).
- Confine the spread of contamination, starting from areas of low contamination and working toward areas of higher contamination.
- When cleaning a work surface with a decontamination solution, always clean from the outside of the contaminated area working inward towards the center. Use a fresh paper towel with each pass and don't wipe the area in a circular fashion.
- Carefully remove all loose or easily removable contamination, then wash with soap, detergent, or special solvents.
- Place used cleaning materials (e.g., absorbent materials, gloves, etc.) in a labeled radioactive waste container.

Glassware and other contaminated equipment should be cleaned using laboratory detergents, acids, or cleaning solutions as appropriate. Contaminated equipment (e.g., pipetters, centrifuge rotors, etc.) can be soaked in a decontamination solution overnight to improve removability of contamination. All equipment that is to be disposed of and is contaminated with long-lived radionuclides, and that cannot be cleaned to acceptable levels, must be disposed of as radioactive waste. Equipment contaminated with short-lived

radionuclides and being stored to allow for radioactive decay must be clearly identified and stored in a secure location.

Material and equipment exposed to unsealed radioactive material must be thoroughly decontaminated and properly surveyed to confirm the absence of residual radioactive material before it is released for unrestricted use. Proper survey equipment and techniques must be used and the results documented before the material is released. The RST should be consulted for any questionable situations or complex equipment like liquid scintillation counters and gas chromatographs that might contain sealed sources or contamination.

Hazardous and radioactive materials cannot be sent to Overstock for release to the public.

Contact the RST for questions related to disposal of radioactive material.

6.15 UC Berkeley Contamination Limits

Levels of contamination on radioactive work surfaces, equipment, and facilities should be kept as low as reasonably achievable (ALARA). Maximum acceptable levels of contamination are listed in Table 4 below. These levels can be determined by the use of an appropriate survey meter or area wipe. Workplace surfaces and floors that cannot be decontaminated to acceptable levels should be brought to the attention of the RSO to determine how they will be addressed.

Table 4. UC Berkeley Contamination Limits

TYPE OF SURFACE	**dpm/100cm^2**	**α emitters dpm/100cm^2**	**β, X or γ emitters Radiotoxicity[2] level 3, and 4 dpm/100cm^2**	**β, X or γ emitters Radiotoxicity[2] level 1 and 2 dpm/100cm^2**
Restricted and Controlled Areas				
Within posted radioactive materials zones[1]	1,000 α 10,000 β, X or γ	200	2,000	10,000
Outside posted radioactive materials zones[1]	100 α 1,000 β, X or γ	20	200	1,000
Skin, personal clothing, and protective clothing	Not statistically different from background* Typically this means less than twice the background count rate with an appropriate sensitive contamination survey instrument.			
Unrestricted Areas				
All surfaces, including items removed from restricted and controlled areas and "trash"	Not statistically different from background.			

1. Total-includes removable and fixed contamination
2. See Appendix 1 section 1.2 for specific radiotoxicity values.

X = X-ray β, = beta α = alpha γ = gamma

6.16 Sealed Sources

- A physical inventory of licensed sealed sources is required to be completed and documented once every six months.
- Most sealed sources must be leak tested every six months. The RST will perform these tests and advise the RH of the results and any actions that should be taken.
- In many cases, only vendor representatives are authorized to remove or replace sealed sources installed in manufactured devices. Contact EH&S RST for assistance.

7 PROCEDURES FOR WORK WITH RADIATION PRODUCING MACHINES

The UC Berkeley campus uses a wide variety of ionizing radiation–producing machines (RPMs). They are classified as follows:

- Class 1- Electron microscopes or other low-hazard machines
- Class 2- Cabinet X-ray machines, X-ray diffraction and fluorescence analysis machines, XRF machines, portable X-ray machines, diagnostic X-ray machines, or other medium hazard machines
- Class 3- Accelerators or other unique high hazard X-ray machines

The Radiation Safety Committee will review any unique x-ray equipment that does not clearly fit into these categories and will determine the proper classification for the unit.

7.1 Possession of RPMs- Procurement or Transfer

- Notify the RSO before bringing an RPM onto campus. The RSO must register most machines with the CDPH within 30 days. However, in the case of machines with an operating potential of greater than 500kVp or which are capable of producing a significant radiation hazard, UC Berkeley must notify the CDPH at least 60 days before taking possession of the machine or before starting construction or reconstruction of the room where the machine will be housed (whichever comes first.)
- Apply for an RUA before acquiring or operating the machine, regardless of the means of acquisition (purchase, lease, gift, loan, "in-house" fabrication) and regardless of ownership.
- All individuals must complete the RPM Safety Training to be listed on an RUA. Electron Microscope users are the exception and they do not require RPM training or to be listed on the RUA. They only require machine specific training by the RH or Lab Contact. The Electron Microscope RH and Lab Contact are required to have RPM training.
- Notify the RSO before removing an RPM from campus. The RSO must notify the CDPH within 30 days.
- Notify the RSO if you deactivate an RPM or render it incapable of producing radiation. The RSO must notify the CDPH within 30 days. Label machines that are deactivated but left on campus with the words:

"DEACTIVATED RADIATION-PRODUCING MACHINE

Do Not Move or Operate or Reactivate Without Notifying EH&S Radiation Safety.

CALL (510) 642-3073

7.2 RPM Use

- Operate RPMs in accordance with a valid RUA. Among other items, the RUA lists the RH and other users and describes the machine, operating parameters, procedures, locations, dosimetry, and safety precautions to be used.
- Immediately notify the RSO of intended changes in personnel, machine location, machine repair, operating parameters, or other items in the RUA.
- Do not bypass safety interlocks except as specified on the approved RUA SOP (usually for test and/or alignment purposes). Record authorized bypass operations in the "Use Log".
- Notify the RSO immediately if any safety interlocks fail to operate as intended or if you suspect an accidental exposure.

7.3 RPM Personnel

- Each RPM is controlled by an RH, who is responsible for ensuring compliance with applicable rules and procedures by all operators.
- The RH and users must have adequate knowledge to ensure safe operation and RUA compliance with the RSM.
- Operators of cabinet x-ray machines and portable units meeting the definition of industrial x-ray machines must pass written examinations addressing operation, safety and emergency procedures.
- Machines may only be used by, or under the direct supervision of, an approved operator listed on the RUA.
- A qualified authorized repair person may operate a machine during setup, testing, and repair, and does not need to be on the RUA. If there is any question as to the work to be done or the qualifications of the repairperson, contact the campus RSO.

7.4 RPM Personal Protective Equipment (PPE)

PPE should be used when it will effectively protect parts of the body that may be exposed to X-rays. In general, PPE such as leaded aprons, gloves, and/or goggles are useful only for low-energy (<100 kVp) X-ray sources. PPE does **not** substitute for required engineering controls.

7.5 RPM Location

As a general safety precaution, locate an RPM in a dedicated room or in an area that can be controlled and secured, away from high-occupancy areas.

Observe the following precautions when installing or relocating an RPM:

- Intercept primary beams by use of a primary barrier (unless the beams are confined or limited by other means).
- Locate RPMs in controlled areas so that personnel are not irradiated.
- Control scatter/secondary radiation to reduce radiation exposure.
- Obtain prior approval from the RSO for any change in location of an RPM (unless the RUA specifies otherwise, this requirement applies to portable as well as other RPMs.)
- Rooms containing RPMs must be locked or under the control of RUA personnel such that measures can be effectively taken to prevent the unauthorized use or removal of the RPM. If non-RUA authorized users are permitted to be in the room, then the RPM must be either under constant surveillance by RUA personnel or locked such that it cannot be used, operated or removed by an unauthorized individual.

7.6 RPM Posting and Labeling

- Each machine must clearly display a valid RUA.
- Each machine must be clearly and visibly labeled to caution individuals that radiation is produced during operation.
- "Radiation Area" or "High Radiation Area" must be posted as required.
- A copy of the UC Berkeley "Radiation-Producing Machine Safety Requirements" must be posted in the immediate vicinity of each machine.

7.7 Radiation Surveys

EH&S conducts surveys of every campus RPM as follows:

- Before routine use starts
- Following any major changes in configuration or repair
- Routine surveys including testing for radiation leakage and power/shutter status indicators are done over a range of time periods based on the hazard associated with the machine and use. The specific survey frequency for each RPM is noted in the RUA. All RPMs shall be surveyed at minimum annually. The typical survey frequency range for the different class RPMs is as follows:
  - Class 1 RPM - annually to semi-annually
  - Class 2 RPM - semi-annually to quarterly
  - Class 3 RPM – quarterly to monthly

The required documentation on surveys and tests are specified in the RUA.

7.8 RPM Facility Review and Inspections

The RSO or RSO-designated EH&S staff does the following:

- Reviews all campus building plans that include RPMs.
- Inspects new or modified RPMs or facilities before operation starts, to determine their safety for the intended use and their compliance with federal, state, local, and campus regulations.
- Performs frequent inspections to ensure the machines' ongoing safety and compliance including verification of interlocks, when required.

7.9 RPM Dosimetry

Most Class 2 and 3 machines require the use of dosimetry. The dosimeters are issued by EH&S, and must be worn as specified by the RUA. Dosimetry is not normally required for personnel whose radiation-related duties are limited to working around electron microscopes, X-ray fluorescence units, and other self-contained low–"current/potential" machines. The RSO will determine when dosimetry is required.

7.10 RPM Safety Devices

Federal, state, and local regulations for radiation-producing machines require that they be equipped with certain safety devices. These typically include a fail-safe warning light, fail-safe interlocks, beam enclosures, and shielding. In addition, a radiation survey meter may be needed.

The following procedures apply to all RPMs:

- Safety devices must be in working order before the machine is operated.
- Only authorized repair persons may operate an RPM without using specified, operable shielding and other safety devices.
- Any changes to these safety devices must be reviewed by the RSO. Do not replace or modify safety devices without pre-approval.
- No safety device is absolutely fail-safe or foolproof. Interlocks, like those on the door of a cabinet x-ray unit should not be relied on to automatically close the beam shutter. If an interlock is used to secure a beam, a radiation survey should be performed each time to verify the absence of radiation before placing a part of the body where the beam (or scatter from the beam) might be expected.
- Safety devices must **not** be purposely defeated, even when their use makes operating the machine difficult or impossible. If the design of a safety device prevents or inhibits operation, the RSO may approve an alternate safety device or method of equal protective value. (If safety devices are modified, it may be necessary to modify existing operating procedures or the RUA, and to retrain operators.)
- Do not operate a machine if a required safety device fails. Do not use the unit until it has been repaired and then checked by EH&S.

- Immediately notify EH&S if an unexpected personnel radiation exposure occurs or is suspected to have occurred. Any overexposed dosimeter is considered presumptive evidence of exposure to the individual to whom the dosimeter was assigned.

7.11 RPM Standard Laboratory Operating Procedures (SOP)

An SOP for each RPM must be established that describes in adequate detail how the machine is used and all safety measures that must be observed. Each user of an RPM must read the unit-specific SOP.

7.12 RPM Use Log

Maintain a "Use Log" for all RPMs. This log can be helpful when investigating incidents and/or determining a machine's operating status and reliability. At minimum, the Use Log must note the following information each time the machine is used:

- Date of use
- Name of the operator(s) and RH if more than one RUA/person is using this machine
- Description of use
- Beam voltage
- Beam current
- Time beam turned on
- Time beam turned off
- Operational abnormalities, repairs, etc.

7.13 Security of RPMs

The RH is responsible for the ongoing custody and security of any RPM listed on the RUA. Any loss or potential loss of an RPM must be reported to EH&S (510-642-3073) as soon as possible after the loss is suspected.

Rooms containing an RPM must be locked or under the control of RUA personnel such that measures can be effectively taken to prevent the unauthorized use or removal of the RPM. If non-RUA authorized users are permitted to be in the room where the RPMs is present, the RPM must be either under constant surveillance by RUA personnel or locked such that it cannot be used, operated or removed by an unauthorized individual.

7.14 Specific Requirements by Machine Type

The requirements below cover a range of radiation-producing machines commonly used on campus. Be sure to identify and meet the listed conditions that pertain to the RPM(s) covered by your RUA.

7.14.1 Electron Microscopes

- Valid and current RUA with operator name
- Training
- Operating log
- Adherence to RUA requirements
- Notification to EH&S of any changes to use, machine, personnel, or protocol.

7.14.2 Diagnostic Medical Machines

- Valid and current RUA with operator name
- Posting of CDPH certificate
- Training
- Operating log
- Dosimetry, as assigned
- Adherence to RUA requirements
- Notification to EH&S of any changes to use, machine, personnel, or protocol.
- Regular documented service

Note: All human-use machine operations, installation designs, etc., must be in accordance with published CDPH regulations and the recommendations of the National Council of Radiation Protection (NCRP) EH&S provides oversight of these operations, installation designs, etc. to make sure this requirement is met.

7.14.3 Cabinet X-ray Machines

- Valid and current RUA with operator name
- All operators must pass the RPM Safety Training and practical examination for that machine
- Operating log
- Dosimetry, as assigned
- Adherence to RUA requirements
- Enclosure. These units must use shielded boxes or be used in shielded rooms such that (1) no radiation levels outside the shield exceed 2 mrem per hour, (2) no person is within the shield at any time while the machine is producing X-rays, and (3) all shield entrances are interlocked in some manner so that any attempt to enter will shut off the machine.
- X-ray indicator(s). Each unit must have a conspicuous fail-safe warning light or device that indicates whether the X-ray tube is energized. The light must be placed near the X-ray tube assembly and labeled “X-ray on.”

- Safety-device approval. All interlocks, indicators, and other safety devices must be checked and approved by the RSO or RSO-designated EH&S staff prior to use.
- Survey. The RUA indicates if any surveys are required, and the required schedule.
- Notification to EH&S Radiation Safety of any changes to use, machine, personnel, or protocol.
- Interlocks shall be annually tested to ensure they function as designed and the results documented. Failure of any interlock to function must be documented, reported to the RSO and power to the machine locked out until repairs are made and the RSO inspects the effectiveness of corrective actions.

7.14.4 X-ray Diffraction and Fluorescence Analysis Machines

- Valid and current RUA with operator name
- Training
- Operating log
- Dosimetry, as assigned
- Adherence to RUA requirements
- Procedures and records: Normal operating and alignment procedures are to be documented and readily available.
- Beam stop. Each port must have a beam stop that limits the dose rate immediately behind it to less than 2 mrem per hour at maximum settings.
- Locks. Secure unused ports with key-operated power switches so that the key cannot be removed during operation. Do not leave the key in the port lock when the machine is not in operation.
- X-ray indicator(s). Each machine must have a conspicuous fail-safe warning light or device that indicates whether the X-ray tube is energized. The light must be placed near the X-ray tube assembly and labeled “X-ray on”.
- Safety-device approval. All interlocks, indicators, and other safety devices must be checked and approved by the RSO prior to use.
- Beam enclosure. During routine operation, the primary beam path must be enclosed in a chamber that cannot be entered by any part of the body. The enclosure should be interlocked with the tube high-voltage supply or shutter so that the beam cannot be available unless the enclosure is in place.
- Shutter interlock. If an interlocked beam enclosure is not used, each port’s beam shutter must be interlocked with the accessory apparatus coupling or collimator so that the port can only open if the accessory is in place.
- “Shutter open” indicator. If an interlocked beam enclosure is not used, each port must be provided with a fail-safe “shutter open” indicator.
- Allowable radiation levels. The radiation level outside a beam enclosure typically are limited so that does is 2 mrem per hour or less.

- Survey instrument. An operable radiation-survey instrument must be easily accessible for use with each machine at all times. This instrument must be used to monitor each initial setup and each significant modification thereof for excessive leakage, unsuspected beams, and other hazardous radiation conditions.
- Notification to EH&S Radiation Safety of any changes to use, machine, personnel, or protocol.
- Interlocks shall be annually tested to ensure they function as designed and the results documented. Failure of any interlock to function must be documented, reported to the RSO and power to the machine locked out until repairs are made and the RSO inspects the effectiveness of corrective actions.

7.14.5 Field Radiography

- Special controls are required for field radiography (as stated in 17 CCR§30336.1.)

7.14.6 Miscellaneous Machines

Any machine that does not fall into the categories above is considered a miscellaneous machine. Particle accelerators, demonstration Crookes tubes, and high-voltage supplies are examples of miscellaneous machines. Specific regulations for such machines are listed on the RUA, and may be similar to those required for the other machine categories.

8 RECORD KEEPING

8.1 RUA Holder — Maintained Records

The Radiation Safety Information System (RSIS) is an online application that houses the information about authorized radioactive material and radiation use on the campus. RH's and authorized users have access to RSIS to review your RUA, make amendment requests, request approval of purchase requests, order radioactive waste pick-up's and to maintain your inventory.

RHs must maintain self-survey records related to the uses of radiation specified in their RUAs. These records must be available for review by EH&S and state inspectors. At RUA termination, the RST may request that these records be given to them for archiving.

Laboratory-maintained records include the following:

- A copy of the current RUA
- Standard Operating Procedures (SOPs) associated with this RUA.
- Copies of RUA self-surveys and any corrective actions taken.
- Documentation of RUA specific training including training given to ancillary personnel.
- Records of radioactive waste characterization.

9 RADIOACTIVE WASTE MANAGEMENT

The EH&S Radioactive Waste Management Program is designed to protect individuals and the environment. All radioactive waste must be transferred to EH&S for disposal. Radioactive materials on an RUA may not be released into the sewer, air or disposed of in the regular trash. Exceptions when appropriate can only be made by the Radiation Safety Committee.

See **Appendix 2** for the "**Radioactive Waste Requirements**" document that explains general waste handling and processing, waste handling precautions, as well as detailed instructions for the following types of radioactive waste:

- **Radioactive Solid Waste**
- **Radioactive Liquid Waste**
- **Scintillation Waste**
- **Miscellaneous Radioactive Waste**

10 EMERGENCY PROCEDURES

When an emergency (fire, explosion, chemical exposure, or other event that endangers life and/or property) is accompanied by the presence of radioactive material and radiation, it is important to deal first with those hazards that have the greatest potential impact. Fire, injuries and all life-threatening situations take precedence over radiation issues.

In an academic setting, the quantities and types of radiation used are generally at levels low enough that fire and medical response personnel can deal with severe threats to life, health, and/or property without concern for the radioactive materials and radiation present. Nonetheless, responders should use their usual personal protective equipment (PPE), be monitored for radioactive material contamination, and be decontaminated (as necessary) after addressing the problem at hand and before leaving the scene.

The RSO must be notified immediately of any of the following situations:

- Skin contamination
- Ingestion of radioactive material
- Unexpected personnel exposure
- Severe contamination of equipment or areas
- Spread of contamination, or difficulty cleaning up a contaminated area
- Loss or theft of radioactive materials or radiation-producing machines (RPMs)

When in doubt, CALL EH&S (510-642-3073).

Spills or unplanned releases of radioactive material must be promptly controlled and immediately reported to EH&S RSO. The RSO will determine needed actions and whether the incident must be reported to the CDPH.

10.1 Personnel Contamination

In the case of personnel contamination, immediately call or have someone call EH&S 510-642-3073 to ensure that the RSO is notified. During off hours, call **911** from a campus phone or 510-642-3333 from your cell phone to reach the UCPD emergency line and ask for radiation safety assistance.

In the case of a radiation accident, follow these steps:

1. Treat medical problems first and administer first aid as appropriate. Ask others in the area to assist. First aid and prompt medical treatment take precedence over decontamination. Usually decontamination can wait until the victim is in stable condition.
2. Immediately remove contaminated clothing and flush skin with water.
3. For skin contamination, follow these decontamination procedures:
    a. Wash the contaminated area using a mild soap and lukewarm water. Do not use hot water or break or abrade the skin. Do not use brushes that could damage the skin.

b. If the contamination is widespread, a shower with mild soap and warm water will usually remove most of the contamination. After the shower, survey the person to determine the effectiveness of the decontamination and to localize any remaining contamination.

c. The RSO may recommend additional or specialized decontamination efforts if further decontamination is needed.

4. Bag contaminated clothing and materials**.** EH&S will provide details on decontamination or disposal.

10.2 Procedures for Major Spills

Notify everyone not involved in the spill to leave the immediate area but assemble nearby. Call or have someone call EH&S RST (510-642-3073). During off hours, call UC Berkeley Police at 911 (510-642-3333 by cell phone) and ask for radiation safety assistance.

1. Assess everyone who could possibly have been contaminated.
2. Once potentially contaminated persons have been surveyed and found free of contamination, record their names and release them. When feasible, use reasonable effort to confine contamination.
3. Prevent inadvertent entry or re-entry into the contaminated area. Post all entrances to the room or area with sign(s) warning others that a spill of radioactive material has occurred. Post similar signs in the general vicinity, indicating the location of the spill.
4. Wait for EH&S direction before taking further action. Follow the instructions of the RSO and/or EH&S staff regarding decontamination techniques, surveys, provision of bioassay samples, requested documentation, etc.
5. Do not allow work to resume in the area until approved by the RSO.
6. Place contaminated clothing and materials in bags labeled with contents, radioisotope, and date.

10.3 Procedures for Minor Spills

1. Notify all persons in the area that a spill has occurred.
2. Allow only necessary personnel to enter the area.
3. Put on personal protective equipment (PPE) as necessary.
4. Call EH&S (510-642-3073). During off-hours, call **911** (510-642-3333 by cell phone) and ask for radiation safety assistance.
5. Prevent the spread of contamination by covering the spill with absorbent paper. (If solids are spilled, paper should be dampened.) Use absorbent paper as needed to clean up the spill.
6. Perform frequent surveys with an appropriate meter or machine to determine the effectiveness of the decontamination process.

7. During and after cleanup, carefully fold the absorbent paper with the clean side out and place in a labeled plastic bag. Put contaminated gloves and any other contaminated disposable material in the bag.
8. Survey the area with a meter or other appropriate technique. Check the area around the spill for residual (sometimes called "fixed") contamination.
9. Survey all persons involved in the decontamination process; check hands, clothing, and shoes for contamination. Once personnel have been surveyed and found free of contamination, record their names and release them.
10. If personal contamination is detected, follow the procedure described above under "Personnel Contamination."

10.4 Procedures for Radiation Producing Machine (RPM) Accidents

- TURN OFF MACHINE. If possible, de-energize circuit breakers.

  Call or have someone call EH&S RST (510-642-3073). During off-hours, call 911 (510-642-3333 by cell phone) and ask for radiation safety assistance.
- Treat medical problems first and administer first aid as appropriate. Treatment of injuries takes precedence over radiation exposure.
- Notify the RH and others in the area.
- Record all pertinent information about the incident, including operating voltage and current, exposure time, and distance from the radiation source. Provide this information to the RSO.

Note: Exposure to the primary beam of many x-ray machines can produce significant biological effects that are not immediately apparent. The RSO must be immediate notified and will initiate consultation with competent medical representative to assess dose and ensure proper medical follow-up.

APPENDIX A-Radiation Use Authorization (RUA) Application Process

Requests for use of radioactive materials and/or radiation-producing machines (RPMs) under the campus license are initiated by the prospective RUA Holder by submitting the applicable applications forms. These requests are processed as follows.

1.0 RSO Review

The RSO or a designee reviews the completed application form and conducts a detailed review of the proposed project. Normally this review includes a personal interview with the applicant and an inspection of the proposed workplace(s). Training, experience of the applicant, the radioisotope, its activity, and its chemical and physical form, experimental protocol, adequacy of all workplaces, ALARA practices, monitoring methods, radiation-detection equipment, contamination-control procedures, waste practices, etc.

Based on the analysis, a Hazard Guide Value (HGV) is calculated, in order to establish the classification of the use as Class 1, 2, or 3 (low, medium, or high radiological hazard.)

1.1 Determination of the Hazard Guide Value (HGV)

Each proposed RUA is assigned an HGV according to the method below. This value determines the RUA classification and the depth of review required for approval or renewal. The RUA's HGV is the sum of the highest individual HGVs for each listed radionuclide, experiment, order or possession unit and is calculated using this formula:

Individual HGV = Qi Ti U_i Wi

Where:
Q_i = Quantity of a radionuclide in microcuries

T_i = Relative Toxicity Factor

U_i = Use Factor

Wi = weighting factor for experiment, order, or possession

Total HGV = sum of the highest individual HGVs for each listed radionuclide

1.2 Factors Used in HGV Formula

- Quantity of the radionuclide is expressed in microcuries.
- Relative Toxicity Factor (T_i) is based on 10 CFR §20, Appendix B, Table 1. The T_i of DNA-seeking compounds is increased by a factor of 10 for H-3, C-14, and I-125.

Table 5: T_i Values for Radioisotopes According to Relative Radiotoxicity

Relative Toxicity Factor	Radioisotopes
Very High 100	Pb-210 Po-210 Ra-223 Ra-226 Ra-228 Ac-227 Th-227 Th-228 Th-230 Pa-231 U-230 U-232 U-233 U-234 U-235 Np-237 Pu-238Pu-239 Pu-240 Pu-241 Pu-242 Am-241 Am-243 Cm-242 Cm-243 Cm-244 Cm-245 Cm-246 Cf-249 Cf-250 Cf-252
High 10	Na-22 Cl-36 Ca-45 Sc-46 Mn-54 Co-56 Co-60 Sr-89 Sr-90 Y-91 Zr-95 Ru-106 Ag-110m Cd-115m In-114m Sb-124 Sb-125 Te-127m Te-129m I-124 I-125 I-126 I-131 I-133 Cs-134 Cs-137 Ba-140 Ce-144 Eu-152 Eu-154 Tb-160 Tm-170 Hf-181 Ta-182 Ir-192 Tl-204 Bi-207 Bi-210 At-211 Pb-212 Ra-224 Ac-228 Pa-230 Th-234 U-236 Bk-249
Moderate 1	Be-7 C-14 F-18 Na-24 C1-38 Si-31 P-32 P-33 S-35 Ar-41 K-42 K-43 Ca-47 Sc-47 Sc-48 V-48 Cr-51 Mn-52 Mn-56 Fe-52 Fe-55 Fe-59 Co-57 Co-58 Ni-63 Ni-65 Cu-64 Zn-65 Zn-69m Ga-72 As-73 As-74 As-76 As-77 Se-75 Br-82 Kr-85m Kr-87 Rb-86 Sr-85 Sr-91 Y-90 Y-92 Y-93 Zr-97 Nb-93m Nb-95 Mo-99 Tc-96 Tc-97m Tc-97 Tc-99 Ru-97 Ru-103 Ru-105 Rh-105 Pd-103 Pd-109 Ag-105 Ag-111 Cd-109 Cd-115 In-115m Sn-113 Sn-125 Sb-122 Te-125m Te-127 Te-129 Te-131m Te-132 I-130 I-132 I-134 I-135 Xe-135 Cs-131 Cs-136 Ba-131 La-140 Ce-141 Ce-143 Pr-142 Pr-143 Nd-147 Nd-149 Pm-147 Pm-149 Sm-151 Sm-153 Eu-152 Eu-155 Gd-153 Gd-159 Dy-165 Dy-166 Ho-166 Er-169 Er-171 (9.2 hr) Tm-171, Yb-175 Lu-177 W-181 W-185 W-187 Re-183 Re-186 Re-188 Os-185 Os-191 Os-193 Ir-190 Ir-194 Pt-l91 Pt-193 Pt-197 Au-196 Au-198 Au-l99 Hg-197 Hg-197m Hg-203 Tl-200 Tl-201 Tl-202 Pb-203 Bi-206 Bi-212 Rn-220 Rn-222 Th-231 Pa-233 Np-239
Low 0.1	H-3 O-15 Ar-37 Co-58m Ni-59 Zn-69 Ge-71 Kr-85 Sr-85m Rb-87 Y-9lm Zr-93 Nb-97 Tc-96m Tc-99m Rh-103m In-113m I-129 Xe-131m Xe-133 Cs-134m Cs-135 Sm-147 Re-187 Os-191m Pt-193m Pt-197m Th-232 Th-Nat U-238 U-Nat

Use Factor (U_i) is based on the proposed use of the radioisotope. Consideration is given to the probability of:

1) Release of the radioisotope to the environment,

2) Contamination of persons engaged in the operation, and

3) Contamination of equipment and facilities.

Here are some examples:

Table 6: Use Factors

Type of Operation	Typical Use Factor (U)
Sealed sources	0.001
Storage of unsealed radionuclides	0.01
Simple wet operations (e.g., dilution, transfers, closed systems with appropriate traps used in hoods)	0.1
Sealed sources with thin windows; normal chemical operations (e.g., chromatography, filtration, centrifugation, animal injections)	1.0
Simple dry operations	10.0
Transfer and manipulation of dispersible material or complex wet operations	10.0
Production and use of volatile material; complex dry operations (e.g., crushing, mixing)	100.0

- Weighting factor (Wi) recognizes the change in risk associated with different phases of use for the purposes of the HGV determinations:

Table 7: Weighting Factors

Phase	Factor
Experimentation	1.0
Order handling	0.1
Storage	0.01

1.3 Determination of RUA Classification for Radioactive Material and RPM Use

The RUA classification is as follows:

Class 1- Low Hazard

- Radionuclides with HGV 0-500

- RPM's –electron microscopes; on-hold or non-operational RPM's; other electronic devices with low personnel exposure potential

Class 2- Medium Hazard

- Radionuclides with HGV 500-50,000
- RPM's- most diffraction, industrial radiography, diagnostic, cabinet, XRF, and portables

Class 3- Higher Hazard

- Radionuclides with HGV >50,000
- RPM's- most accelerators and other high hazard devices or as designated by the RSO.

1.4 Determination of RUA Dosimetry and Bioassay Requirements

Personnel exposure monitoring is provided if a person is likely to receive a radiation doses in excess of 10 percent of CDPH limits. Dosimetry is also required for individuals entering an area of "high" radiation (>100 mrem/hour). The RSO reviews the RUA uses, radionuclides, and amounts and determines what dosimetry and bioassay requirements will be required.

1.5 Determination of Survey Instruments for RUAs

The RSO reviews the RUA uses, radioisotopes, and amounts and determines what survey meters are required. Survey meters must be calibrated for their intended purpose and should be checked prior to each use to confirm they are in good working order (batteries, etc.) and respond appropriately to a known source of radiation.

1.6 Determination of Frequency and Types of EH&S Radiation Safety Surveys of RUAs

The RSO reviews the RUA uses, radionuclides, and amounts. Using the procedures below, the RSO establishes an initial survey (audit) frequency for EH&S radiation safety surveys of the RUA. This is typically indicated on the RUA.

These surveys are typically categorized for radioactive material and RPM's as follows:

- **Routine**- monthly- quarterly-Class 3; quarterly-semi-annual Class 2; semi-annually-annual Class 1
- **Renewal-** typically not less than once every year;
- **Termination**;
- More frequently surveys are conducted for new users, based on need or for experienced users based on poor performance.

1.7 Details of the Radiation Safety Surveys (audits)

Routine surveys are performed in order to ensure that radioactive materials are being used properly, that RUA requirements are being met, that requirements of the Radiation Safety Manual (and associated documents) are being met, and that contamination and radiation levels are within administrative requirements.

Renewal surveys entail a more detailed review than routine surveys. In addition to the routine survey elements, in a renewal survey the radiation safety surveyor meets with the RUA RH or his/her laboratory contact and reviews the SOP protocol(s) and reviews the compliance history for the RUA for the past year.

Special surveys are performed as needed to address issues in the laboratory. An example would be a spill.

Termination surveys are performed if a user will be ceasing operations that use radioactive materials. The scope of the survey is determined by the history of use and by the intended future use of the space. That is, a survey of a laboratory area that will be used by another RUA Holder for radioactive materials use will be different from one for unrestricted release.

Vacating surveys are performed to release a building or authorized use location for unrestricted use. These surveys must be approved in advance by CDPH.

1.8 Frequency of EH&S Radiation Safety Surveys

Audit (EH&S survey) frequency is based on potential hazard as determined by the RSO.
The RSO or designee's review establishes an initial radiation safety survey for EH&S. However, survey frequency can be modified by the RSO based on RUA compliance, use changes, or professional judgment.

1.9 Frequency of RUA Holder (RH) Self-Surveys

RH self- survey frequency is specified on the individual RUA. The following conditions must also be met:

- A documented self-survey must be conducted of the immediate work area after all iodinations, and if more than one mCi of any other radionuclide is used.
- Problems found during self-surveys must be corrected, and the RH must document the correction(s). Problems such as spills, lost dosimetry, and injuries must be reported to the RSO. EH&S periodically reviews self-survey documentation.
- The minimum user self-survey frequency is indicated on the RUA. Required survey frequencies may be modified at the discretion of the RSO or RSC.

1.10 Determination of Additional Required Precautions

The RSO uses a combination of typical requirements, experience, and professional judgment to determine any additional required precautions. The RSO updates these required precautions based on performance of the RUA and other issues.

2. RUA Holder (RHs) Review

Once the Standard Operating Procedures (SOPs) are finalized, the RST sends the pending RUA to the RH, who signifies agreement and approval by signing the RUA and by obtaining the signature of the Department Chair. The signed RUA is returned to the RSO.

3. Final Review and Approval

After receiving the signed RUA, the RSO obtains the appropriate RSC approval if needed, making the RUA approval final. Questions or disagreements concerning review and approval of an individual RUA are resolved by the RSC.

3.1 Initial Applications to Use Radioactive Materials and Ionizing Radiation

3.1.1 Class 1 (low radiological hazard)

Initial Class 1- draft RUAs are reviewed by the RSO. The RSO with their discretion may choose to involve the RSC chair. Work cannot start until the RUA approval process has been completed and an approved RUA has been issued. A copy of the approved RUA is supplied to the RSC at their next meeting.

3.1.2 Class 2 (medium radiological hazard)

Following the RSO's review, the pending RUA is submitted to the RSC Chair for review and approval. If the RSC Chair approves the RUA, it is finalized and granted approval. Work cannot start until the RUA approval process has been completed and an approved RUA has been issued. A copy of the approved RUA is supplied to the RSC at their next meeting.

3.1.3 Class 3 (high radiological hazard)

Following the RSO's review, the pending RUA is submitted to the RSC for approval. The full RSC considers the RUA and either votes to approve the RUA or directs the RSO to take actions it recommends. Work cannot start until the RUA approval process has been completed and an approved RUA has been issued.

4. Renewal of RUAs

RUAs are valid for a maximum of one year. Prior to expiration, a renewal survey is performed and an updated draft RUA is prepared. Renewal for each of the three RUA classifications is essentially the same as the initial processing, with the exception that the signatures of the RH and Department Chair remain in effect from the time at which they were last required.

If no planned use of the radioactive materials or RPM is planned for >6 months, it is an option to place the RUA on hold. During the period the RUA is on hold, the RST will usually not perform routine surveys but the RST must perform the semi-annual inventory of radioactive sources.

Normal radiation safety surveys and oversight will resume when RH notifies the RSO that use is to be recommenced. The RH will be instructed to notify the RSO prior to actual work with radioactive materials or radiation producing machines is begun.

5. Notification of Approval

The RSO updates RSIS and notifies the RH of the updated RUA.

6. Termination of RUAs

There are two reasons for termination of an RUA: for cause, and routine.

6.1 Termination for Cause

Any RH found to be willfully and/or negligently violating any campus, NRC, or state regulations governing the RUA may have that RUA suspended or terminated. Examples of termination for cause also include:

- Repeated unnecessary exposure of personnel
- Repeated unnecessary contamination of work areas
- Non-reporting of spills, suspected high exposures, loss of radioactive materials or RPMs
- Non-reporting of required RUA changes (such as isotope or personnel)
- Inadequate security of radioactive materials or RPM
- Use of unauthorized work areas and/or equipment
- Improper acquisition or transfer of radioactive materials
- Improper disposal of radioactive waste

- Disregard for specified laboratory safety procedures or RUA precautions
- Failure to complete required training or annual retraining,
- Failure to pay required monetary fees, and
- Poor "housekeeping"

If violations threaten termination for cause, the Chair of the RSC (or designee) notifies the RH that continued violations will result in RUA termination. If problems remain unresolved, the RSC discusses the situation with the RH. The RSO can immediately suspend any activity that presents an undue or unevaluated risk. The RUA may be provisionally reissued on a monthly or quarterly renewal, during which time improvement is assessed by the RSO and the RSC. The RSC discusses compliance and determines whether to terminate the RUA or take other action.

RSC decisions to revoke or suspend an RUA may be appealed to the Vice Chancellor for Research (VCR). In such cases, the VCR meets with the petitioner and the RSC (or RSC representatives) to determine the appropriate actions. Decisions to modify actions of the RSC are transmitted to the RSC in writing and included in the RH's file.

For conditions that result in imminent (immediately hazardous to life or health) radiological hazards, the RUA may be terminated on the RSO's own authority.

6.2 Routine Termination

Ordinarily, RUAs are terminated upon:

- Completion of the project
- Change in the RH
- Expiration of the RUA
- Rendering the RPMs inoperable
- Termination by RH of relationship with UC Berkeley

6.3 Action Taken on RUA Termination

Upon termination of an RUA, all radionuclides acquired there under must be accounted for to the RSO. Remaining materials must be transferred to another RH who has been authorized to receive them, or disposed of as radioactive waste.

RHs are asked to notify the RSO of a proposed RUA termination sufficiently ahead of time (at least one week) to permit scheduling of termination procedures, including:

- Termination survey
- Return of personnel dosimeters
- Removal of radiation-hazard warning signs
- Removal of radioactive waste
- Removal or transfer of radioactive materials
- Collection of RUA records if needed.

7. Revision and Amendment of RUAs

If a RH determines that a revision of the RUA is required, the request for change must be made to the RSO. Items that require specific pre-approval (via updating the RUA) include any of the following:

- Changes in personnel
- Use of radioisotopes or compounds not listed on the RUA
- Change of use location
- Increase in use or possession limits
- Use of processes or procedures not previously authorized

Changes cannot be implemented until the modification to the RUA has been approved. If a new RUA must be issued, the process for amendment is the same as for each classification's initial RUA application and approval process.

7.1 Revision and Amendment Process

A **revision** of an existing RUA is a minor change that does not affect the safety review previously performed and approved. Examples of revisions include: adding a new person to the RUA, adding a new room, deleting a person from the RUA, or making minor changes to items such as the dosimetry requirement or sink-disposal limits.

An **amendment** to an RUA is a major change that has an impact on the previously performed safety assessment and approval(s). Examples of an amendment include: adding a new radioisotope(s), radioisotope-limit changes that change the Hazard Guide Value and RUA Class, use of a new protocol, the addition of the use of animals, etc. The RSO decides what level of review is required by the amendment.

Appendix B-UC Berkeley, Radioactive Waste Requirements

This document contains information on radioactive waste collection, packaging, labeling, storage and disposal. Users are required to make efforts to reduce the amount and activity of radioactive waste. These efforts will help provide a safe working environment, reduce the volume of waste generated by the campus and decrease disposal costs.

Federal and state rules and regulations and the state-granted campus Radioactive Materials License provide requirements for radioactive material use and disposal. To assist you in meeting these requirements, the following information about the major campus radioactive waste categories are provided.

If you have any questions regarding radiation safety, radioactive waste packing/labeling, please call Environment, Health & Safety (EH&S) at 510-642-3073.

The following are major campus radioactive waste categories, sub-categories and references for radioactive waste disposal.

- **Radioactive Solid Waste-** Dry Waste; Biohazardous Dry Waste; Biohazardous Sharps Waste; Non-Biohazardous Sharps Waste; Biological Solid Waste
- **Radioactive Liquid Waste-** Liquid Waste; Biological Liquid Waste; Biohazardous Liquid Waste; Mixed Waste; Liquid Stock Vials
- **Scintillation Waste-** Liquid Scintillation Counting (LSC) Vials; LSC Standards; List of Biodegradable LSC Cocktails; Bulk Liquid Scintillation Fluids
- **Miscellaneous Radioactive Waste-** Tritium (^{3}H) Exit Signs and Smoke Detectors; Miscellaneous Radioactive Waste

1.0 General Information, Requirements and Precautions

1.1 Radioactive Waste Records/Request Management

All radioactive waste is managed by computer requests in the Radiation Safety Inventory System (RSIS) database. Detailed information on the use of this database is available at the EH&S Radiation Safety website. In summary all unwanted, in process material, stock material or material in local waste containers must be designated as waste by choosing "Request EH&S pickup" or "dispose in Central Pickup" from the drop down menu. When this choice is made you have created a bag of waste. Each bag will have a unique number issued by RSIS. Once you have filled out the form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

1.2 Segregation of Radioactive Waste

Segregation of radioactive waste by radioisotope and physical form (i.e., liquids and solids) is an important element of the campus Radioactive Waste Management Program. When radioactive waste is segregated by radioisotope, it allows us to dispose of short half-life waste through decay.

1.3 Radioactive Sharps

Radioactive waste personnel open and handle waste and could be injured by sharps that are not properly contained. Radioactive sharps include hypodermic needles, syringes with attached hypodermic needles, razor blades, scalpel blades, X-acto® blades, Pasteur pipettes, and glass or plastic that is broken or is expected to break in the process of storage, processing or disposal. LSC vials are not normally handled as sharps waste unless already broken. Refer to "Radioactive Biohazardous Sharps Waste" or "Radioactive Non-Biohazardous Sharps Waste" for information on packaging.

1.4 Decay of Radioactive Waste

Dry waste with radionuclides having half-lives of 120 days or less (short-lived) are managed under the campus radioactive waste decay program. Once decayed, the waste can be disposed of as non-radioactive. Do not decay waste in the laboratory; call EH&S at 510-642-3073 for pick-up.

1.5 Central Pick-Up Unit (CPUs) Locations for Radioactive Waste

If your building has a CPU, dry wastes and scintillation vials must be deposited in the CPU for pick-up. In order to gain access to the CPUs, please contact your Building Coordinator. Once you have created a bag of waste it shows up immediately in the RSIS. You must move the materials to the CPU within a matter of a few hours of the entry in the computer.

1.6 Pick-Up of Radioactive Waste

If there is no CPU in your building, you can schedule a pick-up of radioactive waste; please indicate "Request EH&S pickup" when you create the bag of waste. Allow five working days from the date of your request for pick-up. If you have high-level radioactivity in your waste or a special need, your waste can be picked up right away. Please indicate any special conditions, the exact location of the waste and the contact name and number in the comments section when you create the bag of waste.

1.7 Radioactive Biohazardous Waste

Before pick-up, all biohazardous materials that are also radioactive must be inactivated to render them non-biohazardous. Do not package radioactive waste in biohazard bags. Refer to "Radioactive Biohazardous Dry Waste" or "Radioactive Biohazardous Liquid Waste" for more detailed information on disposal.

1.8 Radioactive Mixed Waste

When radioactive materials and hazardous chemicals are combined, the resultant mixture is a radioactive mixed waste. Radioactive mixed wastes are the most difficult and expensive waste to dispose and manage. You will be recharged at full cost for mixed waste disposal fees.

In addition to the standard Radioactive Waste Program requirements for disposal, mixed waste disposal requires that the waste container be labeled as hazardous waste when the first drop of material is generated. To complete a hazardous waste label, you will use the Hazardous Waste Program available at the EH&S website. To use the HWP you will need a CalNet ID and you will have to complete the ~30 minute hazardous waste training. Once completed, follow these steps:

1) Create a label by filling in the required fields and write "MIXED RADIOACTIVE WASTE" in the comments field,

2) Print the label, and affix it to each container of mixed waste.

3) Request a pickup of the mixed waste before 6 month has elapsed. Use the RSIS application available at the EH&S radiation safety website to request a pickup of radioactive and mixed waste, not the HWP. When requesting a pickup in RSIS another label will be printed with the radioactive and chemical details. Both labels must be affixed to the waste container.

4) After pickup, EH&S will delete the waste item. Small quantities of mixed waste may be rendered non- or less-hazardous by meeting laboratory "Bench Top" treatment regulations. See the EH&S Bench Top Treatment factsheet at the EH&S website.

1.9 Drain Disposal of Aqueous Radioactive Liquid Waste

Effective second quarter 2013, drain disposal of aqueous radioactive liquid waste is no longer allowed in the labs on campus. All aqueous radioactive liquid waste must be collected and managed at the HMF.

1.10 Methods for Reducing the Volume and Radioactivity in Your Radioactive Waste

- Separating radioactive from non-radioactive material
- Segregating radioactive waste by radionuclide and physical form.
- Using short-lived isotopes
- Performing small scale experiments
- Where possible, not mixing radioactive materials with chemicals or biohazardous materials
- Rendering the materials non or less hazardous in the last steps of the experiment
- Emphasizing the importance of reducing the source and generation of radioactive waste

1.11 Further Information

EH&S picks up, stores, decays, processes, and disposes of the campus radioactive waste. EH&S cannot pick-up radioactive waste that is not adequately packaged and labeled. If you have any questions regarding the packaging or labeling of radioactive waste, please call EH&S. Radioactive waste packing labels are available by request. Please call EH&S or ask an EH&S Radiation Safety team member at radsafety@berkeley.edu or calling 510-642-3073.

1.12 Radioactive Waste Handling Precautions

1. Maintain lab specific procedures for waste accumulation and disposal, and train lab personnel.
2. Properly package and label all radioactive waste. Specific instructions are listed below, or contact EH&S with any questions. Using thicker plastic bags and not filling the waste bag to its capacity will allow for safer packaging of the waste, reducing the possibility of spills or other incidents.
3. Keep a log of activity and date when the waste is deposited. This will allow lab personnel to know how much activity is in the waste in order to gauge when it would be proper to transfer the waste to the CPU. It will also facilitate accurate labeling.
4. Use smaller waste receptacles to reduce the amount of waste per disposal. Making more frequent trips to the CPU, instead of accumulating waste in the laboratory will also help reduce the amount of activity in each bag of the waste.
5. Minimize radiation exposure during transport by using a Lucite shielded receptacle with wheels for P-32 waste. This will reduce the time waste is handled. Remember to survey the transported carts before and after the waste transfer.
6. Minimize exposure to others by using the freight elevator without other passengers and by increasing the distance between the source of radiation and the person by using a cart.
7. Work in pairs when transferring waste to the CPU. One person can be gloved and responsible for pushing the waste cart or receptacle and handling the waste, while the other opens doors and calls the elevator.

2.0 Specific Radioactive Waste Handling Requirements

2.1 Radioactive Solid Waste

2.1.1 Radioactive Dry Waste

Radioactive dry waste is dry laboratory debris (i.e. gloves, paper towels, glassware, etc.) that is contaminated with radioactive material. Discarded plastic syringe barrels (without hypodermic needles) that are contaminated with radioactive material may be disposed of as radioactive dry waste.

Radioactive dry waste does <u>not</u> include metallic lead, sealed radioactive sources, smoke detectors, or exit signs that contain radioactive materials, sources that emit alpha radiation (such as uranyl acetate or thorium compounds), or containers with freestanding liquids. Refer to “Miscellaneous Radioactive Wastes” for information on these materials.

Radioactive sharps must be managed, contained and labeled according to specific requirements. Refer to “Radioactive Biohazardous Sharps Waste” or “Radioactive Non-Biohazardous Sharps Waste” for these requirements.

Packaging: Segregate waste by radioisotope. Bag radioactive dry waste in strong, clear plastic bags. Deposit all glassware in a sturdy puncture-resistant container before placing them inside the bags.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Some buildings (Koshland, LSA, Morgan, Li Ka Shing and Stanley) have Central Pick-up Units (CPUs). If your building has a CPU, deposit each labeled and sealed bag in the appropriate drum in the CPU and fill out all information requested on the associated drum log. Do not deposit radioactive dry waste in drums designated for liquid scintillation counting (LSC) vials, etc.

If there is no CPU in your building, package your waste in smaller plastic bags and accumulate your wastes in dry waste boxes, provided by EH&S, in your laboratory. Package and label the bags of waste as described above. P-32 may require shielding the box to reduce the dose rate in your laboratory. For information on shielding, please call EH&S. Allow five working days for pick-up.

2.1.2 Radioactive Biohazardous Dry Waste

Radioactive biohazardous dry wastes are any dry items (such as plastic petri dishes, plastic tissue culture flasks, micro-pipette tips, gloves, paper towels, etc.) that are contaminated with both radioactive material and a biohazardous agent. In general, biohazardous waste contains infectious agents (such as bacteria, fungi and viruses) that can cause illness in humans.

Radioactive biohazardous dry waste must be rendered non-biohazardous prior to pick-up. This is normally performed by use of steam sterilization or by use of bleach to a final concentration of 10%. For waste products containing volatile radionuclides such as I-125, I-131 or S-35, please contact EH&S at 510-642-3073 for assistance prior to the use of steam sterilization or bleach.

If you use steam sterilization, we recommend the use of the Costar® Mixed Waste Bag. These bags come with instructions. Remove biohazard labels following steam sterilization. Contact EH&S if you wish to use an alternative method.

Packaging: Segregate waste by radioisotope. Bag radioactive dry waste in strong, clear plastic bags. Do not package any radioactive inactivated biohazardous dry waste in biohazard bags.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: After the waste is rendered non-biohazardous, it is disposed of as radioactive dry waste. Some buildings (Koshland, LSA, Morgan, Li Ka Shing and Stanley) have Central Pick-up Units (CPUs). If your building has a CPU, deposit each labeled and sealed bag in the appropriate drum in the CPU and fill out all information requested on the associated drum log. Do not deposit radioactive dry waste in drums designated for liquid scintillation counting (LSC) vials, etc.

2.1.3 Radioactive Biological Sharps Waste

Radioactive biohazardous sharps waste includes items that are radioactive, biohazardous, and able to pierce the skin. Sharps include hypodermic needles, syringes with attached hypodermic needles, razor blades, scalpel blades, X-acto® blades, Pasteur pipettes, and glass or plastics that are broken or expected to break in the process of storage, processing or disposal. LSC vials are not normally handled as a sharps waste unless already broken.

Radioactive biohazardous sharps wastes must be inactivated to render it non-biohazardous prior to pick-up. Refer to "Radioactive Biohazardous Dry Waste" for information on inactivating the biohazard. See also "Sharps: Handling and Disposal" EH&S Fact Sheet No. 12 for more information.

Packaging: Segregate waste by isotope. To prevent injury, radioactive biohazardous sharps require special packaging. Deposit inactivated, non-biohazardous sharps into an approved sharps container or into a rigid, puncture-resistant container. Remove biohazard labels from the container.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: After sharps are rendered non-biohazardous, the entire sharps container is disposed of as radioactive dry waste. Some buildings (Koshland, LSA, Morgan, Li Ka Shing and Stanley) have Central Pick-up Units (CPUs). If your building has a CPU, deposit each labeled and sealed bag in the appropriate drum in the CPU and fill out all information requested on the associated drum log. Do not deposit radioactive dry waste in drums designated for liquid scintillation counting (LSC) vials.

2.1.4 Radioactive Non-Biological Solid Waste

Radioactive non-biohazardous sharps waste includes items that are radioactive and able to pierce the skin. Sharps include hypodermic needles, syringes with attached hypodermic needles, razor blades, scalpel blades, X-acto® blades, Pasteur pipettes, and glass or plastics that are broken or expected to break in the process of storage, processing or disposal. LSC vials are not normally handled as a sharps waste unless already broken. See also "Sharps: Handling and Disposal" EH&S Fact Sheet No. 12 for more information.

Packaging: Segregate waste by isotope. To prevent injury, radioactive non-biohazardous sharps require special packaging. Deposit sharps into an approved sharps container or into a rigid, puncture-resistant container. Remove biohazard labels from the container.

Labeling: If you use a sharps container, you must remove or deface any biohazard labels from the sharps container.

Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: The entire sharps container is disposed of as radioactive dry waste. Some buildings (Koshland, LSA, Morgan, Li Ka Shing and Stanley) have Central Pick-up Units (CPUs). If your building has a CPU,

deposit each labeled and sealed bag in the appropriate drum in the CPU and fill out all information requested on the associated drum log. Do not deposit radioactive dry waste in drums designated for liquid scintillation counting (LSC) vials, etc.

2.1.5 Radioactive Biological Solid Waste

Radioactive biological solid waste contains radioactive material and biological components, which include animals, animal parts, and/or any biological cultures that may putrefy.

Remove and collect contaminated bedding, paper towels, razor blades, syringes, disposable gloves or instruments associated with the biological work. These items are not included in radioactive biological solid waste and are managed as Radioactive Dry Waste, Radioactive Biohazardous Sharps, or Radioactive Non-Biohazardous Sharps.

Packaging: Segregate waste by isotope. Place the radioactive solid biological waste in a strong, clear plastic bag and seal. Apply the label (as described below) to this bag. Place this sealed and labeled bag into another sturdy clear-plastic bag and seal. Verify that the label is visible. Keep these wastes frozen (to prevent putrefaction) until they are picked up by EH&S.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Radioactive solid biological wastes are picked up from laboratories by request. Do not deposit or store this waste in a CPU. When waste is generated use "Request EH&S pickup" from the drop down menu. Allow five working days for pick-up.

2.2 Radioactive Liquid Waste (Aqueous)

2.2.1 Radioactive Liquid Waste

All liquids that have significant levels of radioactivity above background (bkg) will need to be collected as radioactive waste. Please sample 1 milliliter of your wastes and rinses and count the samples in a Liquid Scintillation Counter. Any sample whose count rate is more than three standard deviations above background, e.g.**,** $\boldsymbol{a\ good\ approximation\ is}$: $\boldsymbol{bkg + (3\sqrt{bkg})}$**,** is considered a statistically significant amount of radioactivity above background and must be collected for disposal through EH&S as radioactive waste. Please note that NO sink disposal of radioactive liquids is authorized!

Any aqueous sample with a count rate below this threshold can be disposed of to the sanitary sewer, assuming that it is chemically safe to do so. See the *"Drain Disposal Restrictions for Chemicals"* at the EH&S website for further information. Further assistance on how to radiologically characterize your waste stream is available by contacting Radiation Safety at radsafety@berkeley.edu.

Once you have characterized the waste stream for each of your experimental processes, you may apply the results to all future wastes generated by those processes. Please keep documentation of your waste characterization analysis.

Maintain liquid waste at a pH between 5 and 10. For liquid waste containing iodine maintain the pH between 8 and 10, slightly basic, to reduce iodine volatilization. pH adjustments should be performed during the last steps of the experiment, not in batches of collected liquid or mixed waste. LSC vials are not included in radioactive liquid waste.

Packaging: Segregate waste by isotope. Collect radioactive mixed waste in one-gallon or larger if provided, narrow-neck, screw-top poly containers or other EH&S-approved containers. Do not mix radioactive wastes of different isotopes or mix chemically incompatible solutions in the same container. Call EH&S at 510-642-3073 if you have chemical compatibility or packaging questions.

Place each bottle in a strong, clear plastic bag to provide a contamination-free surface for handling. Store it in a non-breakable secondary container (generally available from your storeroom). Secondary containers must be able to contain all liquid waste without overflowing if the primary container should break. Make sure the container is tightly closed and the plastic bag is sealed shut with tape.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Liquid waste is picked up from laboratories by request or you may deposit radioactive liquid waste in the CPU within the spill tubs or the pre-approved drum if the tub is full. Some isotopes (such as P-32) may require shielding to reduce the dose rate in your laboratory. When waste is generated use "Request EH&S pickup or deposit in the CPU" from the drop down menu.

If the liquid waste contains hazardous chemical components, refer to "Radioactive Mixed Waste" for information on mixed waste. If you have any questions Call EH&S. Allow five working days for pick-up.

2.2.2 Radioactive Biological Liquid Waste

Radioactive biological liquid waste contains radioactive material and biological fluids such as animal blood and body fluids that may putrefy. This category of waste does not include waste contaminated with biohazardous components or human blood and body fluids. Refer to "Radioactive Biohazardous Liquid Waste" for more detailed information.

Packaging: Segregate waste by radioisotope. Collect radioactive biological liquid waste in one-gallon or larger if provided, narrow-neck, screw-top poly containers or other EH&S-approved containers. Do not mix radioactive wastes of different isotopes or mix chemically incompatible solutions in the same container. Call EH&S at 510-642-3073 if you have chemical compatibility or packaging questions.

As a prudent laboratory practice and to reduce odors, add bleach to the waste to reach a final concentration of 10%. CAUTION - Bleach may not be compatible with your liquid waste. If you suspect a compatibility problem, call EH&S for alternatives to bleach.

Place each bottle in a sturdy clear-plastic bag to provide a contamination-free surface for handling. Store the waste in a non-breakable secondary container (generally available from your storeroom). Secondary containers must be able to contain all liquid waste without overflowing if the primary container should break. Make sure the container is tightly closed and the plastic bag sealed shut with tape.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Radioactive biological liquid wastes are picked up from laboratories by request or you may deposit radioactive biological liquid waste in the CPU within the spill tubs or the pre-approved drum if the tub is full. Some radioisotopes such as P-32 may require shielding to reduce the dose rate in your laboratory. Call EH&S for information on shielding. When waste is generated use "Request EH&S pickup or deposit in CPU" from the drop down menu. Allow five working days for pick-up.

NO Drain Disposal of Radioactive Biological Liquid Waste is allowed!

2.2.3 Radioactive Biohazardous Liquid Waste

Radioactive biohazardous liquid waste contains radioactive material and a biohazardous component. In general, biohazardous components are infectious agents (such as bacteria, fungi and viruses) which can cause illness in humans. Human blood and body fluids contaminated with radioactive material are considered to be radioactive biohazardous liquid waste.

Radioactive biohazardous liquid waste must be rendered non-biohazardous prior to disposal. This is normally performed by steam sterilization or bleach to a final concentration of 10%.

CAUTION - Bleach may not be compatible with your liquid waste. If you suspect a compatibility problem, call EH&S at 510-642-3073 for alternatives to bleach.

Packaging: Segregate waste by isotope. Collect radioactive biohazardous liquid waste in one-gallon or larger if provided, narrow-neck, screw-top poly containers or other EH&S-approved containers. Do not mix radioactive wastes of different isotopes or mix chemically incompatible solutions in the same container. Call EH&S if you have chemical compatibility or packaging questions.

Place each bottle in a strong, clear plastic bag to provide a contamination-free surface for handling. Store the waste in a non-breakable secondary container (generally available from your storeroom). Secondary containers must be able to contain all liquid waste without overflowing if the primary container should break. Make sure the container is tightly closed and the plastic bag is sealed shut with tape. Do not package any radioactive waste in biohazard bags.

Labeling: Remove or deface any biohazard labels.

Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Radioactive biohazardous liquid waste is picked up from laboratories by request or you may deposit radioactive biohazardous liquid waste in the CPU within the spill tubs or the pre- approved drum if the tub is full. Some isotopes (such as P-32) may require shielding to reduce the dose rate in your laboratory. Call EH&S for information on shielding. When waste is generated use "Request EH&S pickup or deposit in CPU" from the drop down menu. Allow five working days for pick-up.

NO Drain Disposal of Radioactive Biohazardous Liquid Waste is allowed!

2.2.4 Radioactive Mixed Waste

Radioactive mixed waste contains fluids that are contaminated with radioactive, biohazardous and/or hazardous chemical materials. The hazardous chemical components usually display corrosive, toxic, flammable, or reactive characteristics or a combination of them. Liquid scintillation fluids are excluded from this waste stream. Contact EH&S radiation Safety before generating any mixed waste for evaluation and pricing.

Do not mix other waste with radioactive mixed waste. Radioactive mixed waste is the most difficult and expensive waste to manage and dispose. You will be recharged at full cost for mixed waste disposal fees.

Maintain the waste at a pH between 5 and 10. For wastes containing radioactive iodine maintain the pH between 8 and 10, slightly basic, to reduce iodine volatilization.

In addition to the standard Radioactive Waste Program requirements for disposal, mixed waste disposal requires that the waste container be labeled as hazardous waste when the first drop of material is generated. To complete a hazardous waste label you will use the Hazardous Waste program available at the EH&S website. To use the HWP, you will need a CalNet ID and you will have to complete the ~30 minute hazardous waste training. Once completed, follow these steps:

1) Create a label by filling in the required fields and write "MIXED RADIOACTIVE WASTE" in the comments field.

2) Print the label, and affix it to each container of mixed waste.

3) Request a pickup of the mixed waste before 6 month has elapsed. Use the Radiation Safety Information System (RSIS) available on the Radiation Safety website to request a pickup of radioactive and mixed waste. When requesting a pickup in RSIS, another label will be printed with the radioactive and chemical details. Both labels must be affixed to the waste container.

4) After pickup, EH&S will delete the waste item. Small quantities of mixed waste may be rendered non- or less-hazardous by meeting laboratory "Bench Top" treatment regulations. See the EH&S Bench Top Treatment factsheet available on the EH&S website for more details.

Packaging: Segregate waste by isotope. Collect radioactive mixed waste in one-gallon, narrow-neck, screw-top poly containers or other EH&S-approved containers. Do not mix radioactive wastes of different isotopes or mix chemically incompatible solutions in the same container. Call EH&S if you have chemical compatibility or packaging questions.

Place each bottle in a strong, clear plastic bag to provide a contamination-free surface for handling. Store it in a non-breakable secondary container (generally available from your storeroom). Secondary containers must be able to contain all liquid waste without overflowing if the primary container should break. Make sure the container is tightly closed and the plastic bag sealed shut with tape.

Pick-up: Radioactive mixed wastes are picked up from laboratories by request. Do not deposit or store radioactive mixed waste in a CPU unless pre-approved by EH&S Radiation safety. Some isotopes (such

as P-32) may require shielding to reduce the dose rate in your laboratory. For information on shielding please call EH&S. When waste is generated use "Request EH&S pickup or deposit in CPU (if approved)" from the drop down menu. Allow five working days for pick-up. **Radioactive mixed waste cannot be drain disposed**.

2.2.5 Radioactive Liquid Stock Vials

Radioactive liquid stock vials are fluids that are generally in small quantities and high concentrations of radionuclides.

Since stock vials can often exceed concentration limits in packaging for disposal, it is important to segregate this waste form from all other wastes.

Packaging: Tighten cap and segregate by isotope. Double-bag in clear strong plastic bags. Collect no more than five stock vials per bag. Provide an inventory for each bag.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Do not deposit or store liquid stock vials in the CPU unless pre-approved by EH&S radiation safety. When waste is generated use "Request EH&S pickup or deposit in CPU (if approved)" from the drop down menu. Allow five working days for pick-up.

RADIOACTIVE STOCK VIALS CANNOT BE DRAIN DISPOSED.

2.3 Scintillation Waste

2.3.1 Liquid Scintillation Counting (LSC) Vials

Included in this type of waste are liquid scintillation counting vials generated during radiation safety required self-surveys and radioactive material use experimentation and LSC standards used for calibration of the counters. LSC standards need to be labeled and packaged separately from general LSC vial waste because it contains quenching agents, which are hazardous chemicals, and must also meet the requirements for disposal as Radioactive Mixed Waste. Refer to "LSC Vials – LSC Standards" for detailed information on packaging and labeling LSC standards.

Furthermore, any type of LSC vials waste that contains hazardous liquid scintillation cocktail must meet the recharge authorization requirements for disposal as Radioactive Mixed Waste.

Packaging: Tighten the cap on each vial. Remove or deface radioactive labels and symbols. Remove vials from flats and double-bag them in strong, clear plastic bags. Place labels on the outer bag.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Some buildings (Koshland, LSA, Morgan, Li Ka Shing and Stanley) have Central Pick-up Units (CPUs). If your building has a CPU, deposit each bag of LSC vials in the appropriate drum in the CPU and fill out all information requested on the associated drum log. Do not put LSC vials in dry waste drums etc.

If there is no CPU in your building, deposit the packaged LSC vials in a LSC vial waste box provided by EH&S in your laboratory. Package and label the bags of vials as described above. Maintain a log of the vials you deposit in the box. When waste is generated use "Request EH&S pickup" from the drop down menu. Allow five working days for pick-up.

2.3.2 Liquid Scintillation Counting (LSC) Vials - LSC Standards

LSC standards used in calibrating LSCs contain small concentrations of ^{3}H and ^{14}C with varying degrees of quench.

Packaging: Segregate LSC Standards by isotope. Double-bag them in strong, clear, plastic bags. Leave radioactive labels and symbols intact. Place labels on the outer bag.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: LSC Standards are picked-up from laboratories by request. Do not deposit LSC Standards in CPUs. When waste is generated use "Request EH&S pickup" from the drop down menu. Allow five working days for pick-up.

2.3.3 List of Biodegradable Liquid Scintillation Cocktails

Perkin Elmer LAS	Beckman	Fisher Scientific	National Diagnostics	ICN Biomedical
Opti-Fluor	Ready Safe	Scintisafe 30%	Ecoscint	BetaMax ES
Opti-Fluor O		Scintisafe Econo1	Ecoscint A	CytoScint ES
Poly-Fluor		Scintisafe Econo2	Ecoscint H	Ecolite
Ultima-Flo AP		Scintisafe Plus	Ecoscint O	Ecolume
Ultima-Flo M		Scintiverse BD	Ecoscint 5	Universol ES
Ultima Gold			Uniscint BD	
Ultima Gold AB				
Ultima Gold F				
Ultima Gold LLT				
Ultima Gold MV				
Ultima Gold XR				
Bio-Safe II				
Bio-Safe NA				
Econo-Safe				

This list is not all inclusive. Please feel free to utilize other available biodegradable cocktails. Please call EH&S at 510-642-3073 if you have plans to purchase non-biodegradable (hazardous) LSC cocktails. To dispose of LSC vials consisting of hazardous LSC fluid, it must meet the recharge authorization requirements for disposal as Radioactive Mixed Waste.

SCINTILLATION FLUIDS CANNOT BE DRAIN DISPOSED even if the manufacturer claims them to be non-hazardous.

2.3.4 Bulk Liquid Scintillation Fluids

Bulk liquid scintillation fluids are scintillation fluids contained in large volumes (not in scintillation vials).

Packaging: Segregate waste by radioisotope. Collect bulk liquid scintillation fluids in one-gallon, narrow-neck, screw-top poly containers or other EH&S-approved containers. Do not mix other wastes with scintillation fluids.

Place each bottle in a strong, clear plastic bag to provide a contamination-free surface for handling. Store it in a non-breakable secondary container (generally available from your storeroom). Secondary containers must be able to contain all liquid waste without overflowing if the primary container should break. Make sure the container is tightly closed and the plastic bag sealed shut with tape.

Labeling: Each bag of waste will have a unique number issued by RSIS. Once you have filled out the online form you will be given the opportunity to print a label. This label MUST be on the bag of waste to be picked up by EH&S.

Pick-up: Bulk liquid scintillation waste is picked up from laboratories by request. Do not deposit or store them in the CPU unless pre-approved by EH&S radiation safety. Some radionuclides such as P-32 may require shielding to reduce the dose rate in your laboratory. For information on shielding, please call EH&S. When waste is generated use "Request EH&S pickup or deposit in CPU (if approved)" from the drop down menu. Allow five working days for pick-up.

SCINTILLATION FLUIDS CANNOT BE DRAIN DISPOSED even if the manufacturer claims them to be non-hazardous.

2.4 Miscellaneous Radioactive Waste

2.4.1 Tritium (^3H) Exit Signs and Smoke Detectors

Tritium gas exit signs and smoke detectors containing radioactive sources are generally licensed materials that need to be disposed of as radioactive waste.

In order to dispose of these wastes, a Radiation Safety Services recharge authorization form available at the EH&S website should be submitted to EH&S prior to requesting a pick-up.

Packaging: Collect these items in a sturdy box segregating each by manufacturer.

Labeling: Label each box with the following information, making sure that each item is segregated by manufacturer and accounted for. Department; Date; Building Name; Manufacturer; Date of Manufacture; Quantity per box, total; Model number; Serial number; Radioisotope; Activity.

Pick-up: Once a recharge authorization form is submitted and the items are packaged and labeled as directed above, please call EH&S at 510-642-3073 for pick-up. Allow five working days for pick-up.

*Prior to purchasing tritium (^3H) gas exit signs or any smoke detectors containing radioactive sources, please discuss the possibility of acquiring non-radioactive alternatives with the Fire Prevention Team at EH&S.

2.4.2 Miscellaneous Radioactive Waste

Metallic Lead

In the case of metallic lead (pigs, bricks, and sheets) that has been used for radionuclide shielding, please perform a meter and swipe survey to determine if the lead is contaminated.

If the lead is not contaminated, remove or deface any radiation labels and label as "CLEAN". EH&S can have your clean lead picked up and recycled. There is no recharge for the recycling of lead but an HWP request will be required to initiate the pick-up. The HWP is available at the EH&S website.

A copy of the lead survey results must also be provided to EH&S at time of pick-up. Call EH&S at 510-642-3073 for more information on the proper management of unwanted lead.

If the lead is contaminated, package it in a container strong enough to withstand the weight of the lead. Each package should be no heavier than 60 lbs. Follow the labeling procedures in "Radioactive Dry Waste". Contaminated lead is picked up from laboratories by request and you must have wipe test results available when the lead is picked up. Do not deposit or store lead in a CPU. Call EH&S at 510-642-3073 for pick-up. Allow 5 working days for pick-up.

Alpha Emitters and Uranium/Thorium Compounds

Radionuclides that are alpha emitters require special disposal methods. Prior to disposal, please contact EH&S at 510-642-3073 for information on packaging and labeling your waste.

All disposals or transfers of special nuclear material (SNM) (e.g. Pu-239, U-233, U-235, and uranium enriched in U-235) must be tracked to their original receipt DOE/NRC Form 741 Nuclear Material Transaction Report. The amount to be discarded or transferred must be measured to the nearest tenth of a gram. The chemical, physical form and enrichment must also be recorded so the elemental mass and amount of contained Pu-239, U-235 and U-235 can be calculated. Prior to pick-up by EH&S, all packages must be clearly labeled with the isotope, enrichment, inventory reference number, mass, physical and chemical form, date and name of person preparing the label. Special controls are required if the amount in the package intended for transfer to EH&S exceeds 15 grams of uranium-235 (contained in uranium enriched to 20 percent or more in U-235 isotope) or exceeds15 grams of uranium-233 or exceeds 15 grams of plutonium. Special controls are also required if the combined mass exceeds of 15 grams when computed by the equation, grams = (grams contained U-235) + (grams plutonium) + (grams U-233).

Please also be aware that any off campus transfer or disposal of SNM with more than one gram of contained Pu-239, U-233 and U-235 requires the submission of a DOE/NRC Form 741 by the close of the next business day to the Nuclear Material Management and Safeguards System.

For disposal of uranium and thorium compounds (not SNM), weigh the material to the nearest gram and place each container in a clear plastic bag and seal it tightly. Follow the labeling procedures in "Radioactive Dry Waste", including the metric weight of the contents of the bottle.

This type of waste is picked up from laboratories by request. Do not deposit or store any alpha emitters or uranium/thorium compounds in a CPU unless pre-approved by EH&S Radiation Safety. When waste is generated use "Request EH&S pickup or deposit in CPU (if approved)" from the drop down menu or Call EH&S at 510-642-3073 for pick-up. Allow 5 working days for pick-up.

Sealed Sources

A sealed source is defined as radioactive material that is encapsulated. Many different radionuclides are available as sealed sources. Follow the labeling and packaging procedures in "Radioactive Dry Waste" for disposal. This type of waste is picked up from the laboratories by request. Do not deposit or store them in the CPU. Call EH&S at 510-642-3073 for pick-up and instructions on proper RSIS functions.

Liquid Scintillation Counters

Some liquid scintillation counters contain a radioactive sealed source. This radioactive source must be removed prior to transfer or disposal of the unit. Radiation Safety needs to be present for any source removal and must perform a close-out survey of the machine before it can be transported and disposed of. Call EH&S at 510-642-3073 for pick-up, instructions on proper RSIS functions and details about source removal.

APPENDIX C-Glossary

ACUC: Animal Care and Use Committee

Airborne Radioactive Material: Radioactive material dispersed in the air in the form of dust, fume, mist, vapor, or gas. [Title 10 CFR §20.1004 and Title 17, CCR]

ALARA (As Low As Reasonably Achievable): ALARA is a regulatory concept devised to ensure that every reasonable effort is made to keep exposures to radiation as far below the dose limits as is practical, consistent with the purpose for which the licensed activity is undertaken. ALARA takes into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations. It exists in relation to utilization of nuclear energy and licensed materials in the public interest. [Title 10 CFR §20.1003 and Title 17, CCR]

Ancillary Personnel: Individuals (such as maintenance workers, lab researchers, interns, students, administrative workers, etc.) who are not ordinarily exposed to radiation or radiation-producing machines in the course of their jobs, but whose duties may extend to areas of potential exposure and require basic radiation-safety training.

Background radiation: Ambient radiation from the cosmos, from rocks and soil, or from ^{40}K (radioactive potassium) in the body.

Cabinet X-ray Machine: A machine constructed such that the useful beam is completely contained within a shielded cabinet, room, or other enclosure from which humans are excluded when the beam is on. This does not include medical machines or X-ray diffraction and fluorescence analysis machines (see below).

CAC: California Administrative Code

CCR: California Code of Regulations

CDPH: California Department of Public Health

CFR: Code of Federal Regulations

Controlled Area: An area outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason. [Title 10 CFR §20.1003]. At UC Berkeley, all areas dedicated to use or storage of radioactive materials are designated controlled areas. With permission, non-occupationally exposed individuals may be present in these areas. (See also **restricted area.**)

Curie: A unit of radioactivity corresponding to a disintegration rate of 3.7×10^{10} disintegrations per second.

Declared Pregnant Worker: A women who uses or works near ionizing radiation sources and who has voluntarily informed the EH&S (in writing) of her pregnancy and the estimated conception or due date. The declaration remains in effect until the worker withdraws the declaration in writing. [Title 10 CFR §20.1003 and Title 17, CCR]

CDPH (Department of Public Health): The California Department of Public Health

Dose: A generic term for any of the following: absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent (TEDE). [Title 10 CFR §20.1003 and Title 17, CCR]

Dosimeter, Dosimetry: A device worn or carried for the purpose of measuring and registering an individual's radiation dose. Dosimeters include film badges, thermoluminescent badges (TLD), pocket chambers, pocket dosimeters, and finger rings.

EH&S (Environment, Health & Safety): The Office of Environment, Health & Safety at UC Berkeley.

Electron Microscope: A device that visualizes matter via interaction with high-speed electrons. This includes both scanning and transmission units, regardless of accelerating voltage.

Engineering Controls: Safety features included as an integral part of a laboratory or other facility. Examples include increased ventilation, fume hoods, radiation shielding, and safety interlocks.

Fail-safe: A default protection design. If a fail-safe indicator or light fails, the operation it indicates will automatically cease. For example, if a fail-safe **"X-RAY ON"** light burns out, X-rays will automatically cease to be produced.

HGV (Hazard Guide Value): A computed value that determines the RUA classification and the depth of review required for approval or renewal.

High Radiation Area: A posted, accessible area in which radiation levels from external sources could result in an individual receiving a dose equivalent in excess of 100 mrem in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. [Title 10 CFR §20.1003] (See also **Radiation Area** and **Very High Radiation Area**.)

Human Use: The internal or external administration of radiation or radioactive materials to human beings. [17 CCR §30100 and Title 17, CCR]

Investigation: The formal EH&S Radiation Safety response to any radiological event—for example, in the event that an individual's combined external and internal exposure reaches twice the value of applicable UC Berkeley administrative guidelines.

Ionizing Radiation: (1) gamma rays and X-rays, and (2) alpha and beta particles, high-speed electrons, neutrons, protons, and other nuclear particles. (Sound or radio waves, or visible, infrared [IR] or ultraviolet [UV] light are **not** considered ionizing radiation.) [Title 17 CCR §30100]

Licensed Material: means source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by CDPH or NRC.

Medical Machine: A device used to deliberately expose humans to ionizing radiation for the purpose of medical diagnosis or treatment. This classification is determined by use rather than design.

Member of the Public: An individual who is not exposed to radiation or radiation-producing machines as part of his or her job. [Title 10 CFR §20.1003 and Title 17, CCR]

Minor: An individual less than 18 years of age. [Title 10 CFR §20.1003 and Title 17, CCR]

mrem (millirem): One thousandth of a rem, the special unit that expresses biological damage or risk from radiation. 1millirem = 0.01mSv.

mSv (milliSievert): One thousandth of a sievert (see **Sievert**). 1mSv = 100mrem

NCRP: The National Council of Radiation Protection.

Non-Occupational Dose: The dose received by an individual who does not work directly with radiation (e.g., office worker, maintenance person, building services person, visitor, etc.). See **Public Dose.**

NRC: The Nuclear Regulatory Commission or its duly authorized representatives. [Title 10 CFR §20.1003 and Title 17, CCR]

Occupational Dose: The dose received by an individual in the course of assigned employment duties that involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation. This applies to both the licensee and others. Occupational dose does not apply to members of the public or to dose received from background radiation, medical administration, exposure to individuals administered radioactive material and released in accordance with 10 CFR §35.75, or voluntary participation in medical research programs. [Title 10 CFR §20.1003 and Title 17, CCR]

Personnel Monitoring Equipment: See **Dosimetry.**

Personal Protective Equipment (PPE): Safety equipment used by an individual for protection against expected or unexpected hazards associated with a procedure. Examples include gloves, goggles, shoe covers, and respirators.

Public Dose: 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 dose received from background radiation, medical administration, exposure to individuals administered radioactive material and released in accordance with 10 CFR §35.75, or voluntary participation in medical research programs. [Title 10 CFR §20.1003 and Title 17]

Quality Factor (Q): The factor by which the absorbed dose (RAD) is multiplied to express the biological damage or risk (rem) to an exposed individual.

Radiation: See **Ionizing Radiation.**

Radiation Area: An accessible area in which radiation levels could result in an individual receiving a dose equivalent in excess of five (5) mrem in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. [Title 10 CFR §20.1003 and Title 17, CCR] (See also **High Radiation Area** and **Very High Radiation Area**.)

Radiation-Producing Machine (RPM): Add and move any device capable of producing ionizing radiation when the associated control devices are operated. This does not include devices that produce radiation only by the use of radioactive material. [Title 17 CCR §30100]

Radiation Safety Committee (RSC): A committee appointed by UC Berkeley administration and granted authority by the State of California to authorize and control the use of radiation at the University.

Radiation Safety Officer (RSO): An individual delegated responsibility for the Radiation Safety Program at UC Berkeley.

Radiation Source: Any source that produces electromagnetic or particulate radiation.

Radiation Use Authorization (RUA): An authorization to use radiation, granted by the RSO and/or RSC to an RH.

RUA Holder (RH): An individual, usually a faculty member or person in charge, who has been authorized by the Radiation Safety Officer (RSO) and granted a Radiation Use Authorization (RUA).

Radioactive Material: Any material that emits radiation spontaneously. [Title 17 CCR §30100]

Radioisotope: See **radioactive material.**

Radionuclide: See **radioactive material.**

rem: The special unit that expresses biological damage or risk from radiation. 1 Rem = 0.01 Sieverts

Restricted Area: An area to which access is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Individuals **other** than radiation workers approved for occupational exposure are not permitted in these areas unless escorted by radiation safety staff. [Title 10 CFR §20.1003] (See also **controlled area.**)

RPM: radiation-producing machine

RSC: Radiation Safety Committee

RSM: Radiation Safety Manual

RSO: Radiation Safety Officer

RST: Radiation Safety Team

RUA: Radiation Use Authorization

Sealed Source: Any radioactive material encapsulated in such a way that it cannot be released under the severest conditions likely to be encountered during normal use.

Source Material: Uranium or thorium or any combination of uranium or thorium in any physical or chemical form or ores that contain, by weight, one-twentieth of 1 percent (0.05 %), or more, of uranium or thorium, or any combination of uranium and thorium. Source material does not include special nuclear material

Special Nuclear Material (SNM): (1) Plutonium, uranium 233, uranium enriched in the isotopes 233 or 235, and any other material which the CDPH declares by rule to be special nuclear material after the NRC or any successor thereto, has determined the material to be such, but does not include source material; or (2) any material artificially enriched by any of the aforementioned. [Title 17 CCR §30100]

Standard Operating Procedure (SOP): Standard Operating Procedure

State (the State): The State of California and any of its agencies empowered to establish regulations regarding radiation and/or radioactive materials.

Survey: An evaluation of the safety precautions put in place to protect against radiation hazards related to the production, use, release, disposal, or presence of radiation sources under a specific set of conditions. The evaluation often includes a physical inspection of the source of radiation and its surrounding area using suitable monitoring/sample-collection techniques. (See also **investigation.**)

Sv (sievert): One hundred rem. A special unit that expresses biological damage or risk from radiation. 1 sievert = 100 rem.

UC Berkeley, the University: All locations under the administrative control of the Chancellor of the University of California, Berkeley campus.

Unrestricted Area: An area to which access is neither limited nor controlled by UC Berkeley. [Title 10 CFR §20.1003 and Title 17, CCR].

User: An individual who is listed on an RUA as a user of radiation and has been properly trained.

Very High Radiation Area: A posted and restricted area in which radiation levels from external sources could result in an individual receiving a dose equivalent in excess of 100 mrem in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. [Title 10 CFR §20.1005 and Title 17, CCR] (See also **Radiation Area** and **High Radiation Area**.)

X-ray Diffraction and Fluorescence Analysis Machine: A machine that produces X-ray beams to analyze various substances via X-ray diffraction or X-ray–stimulated fluorescence.