

Radiation Safety Manual

University of California, Berkeley
Office of Environment, Health & Safety

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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.

The RSM addresses:

- the scope of the campus radiation-safety and use control program and associated activities;
- procedures for obtaining authorization to acquire and use radioisotopes and RPMs;
- regulations and procedures for the storage, transportation, and disposal of radioactive materials;
- the radiation-safety and use control responsibilities of RUA Holders (RHs);
- federal, state, and campus maximum permissible radiation exposures;
- minimum requirements for personnel monitoring (dosimetry);
- minimum requirements for posting required signs and information (e.g. radiation hazard warning signs, emergency procedures, information on availability of the radioactive materials license and RSM);
- emergencies involving radioactive materials or radiation.

The RSM governs the safe use of radiation sources at UC Berkeley in conformance with pertinent sections of the Code of Federal Regulations (CFR) and the California Administrative Code (CAC). The Office of Environment, Health & Safety (EH&S) can provide a list of federal and state regulations and statutes.

Note: All references in this manual and its appendices to “radiation” and “radiation producing machines” are intended to mean ionizing radiation.

Every “RUA Holder” (RH) is provided electronic access to the EH&S website containing the current RSM (<https://ehs.berkeley.edu>). The RH must make access to the EH&S website available to all

individuals working with radioactive materials or radiation. | 3

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.

The RSC and RSO have been granted the flexibility to make programmatic changes or revisions to the *RSM* and radiation safety procedures provided these revisions:

- Are documented, reviewed and approved by the RSC,
- Do not violate any regulations or license conditions,
- Do not decrease the effectiveness of the Radiation Safety Program,
- Are not implemented prior to the affected individuals being trained on the revision and,
- The effectiveness of the revisions or changes is evaluated through the Radiation Protection Program audit process.

Non-substantive changes, like corrections or other administrative matters that do not impact compliance with regulatory requirements can be reviewed and approved by the RSO and RSC Chair. | 3

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. | 3

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. The RSC will review and approve an administrative procedure that governs who has responsibility for these lower tier procedures, instructions, or notices and how they will be established, implemented, and maintained. | 3

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.

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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.

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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.

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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.

See Appendix A for an overview of the RSC. See Appendix 2 for details of the RSC responsibilities.

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

EH&S implements the campus radiation safety program. The program includes audits of all authorizations for the use of radioisotopes and Radiation Producing Machines (RPMs). Specific functions of EH&S include, but are 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

See appendix B for an overview of the Office of EH&S.

2.4.1 Director of Environment, Health & Safety

The EH&S 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 Director serves on the RSC representing campus executive management.

2.4.2 Associate Director, Hazardous Material and Radiation Safety

The Associate Director, Hazardous Material and Radiation Safety (ADHMRS), implements the radiation safety and radioactive waste management programs. The Alternate Radiation Safety Officer (ARSO) supervises the radiation specialists and radiation safety technicians implementing the program and reports to the ADHMRS. This organizational element is referred to as the Radiation Safety Team (RST).

2.4.3 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 ADHMRS. See appendix C for an overview; EH&S can provide a full description of the responsibilities of the RSO.

See Appendix C for an overview of the RSO duties. See Appendix 8 for details of the RSO responsibilities.

2.5 Department Chairs and Unit Directors

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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.

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2.6 RUA Holder

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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 or radiation or radioactive material has received sufficient training to control and minimize exposure to themselves and others. The extent of this instruction must be commensurate with the potential radiological health protection problems in that controlled area,
- acquiring both radioactive materials and RPMs only from authorized vendors using authorized methods. The RH ensures that purchase request for radioactive materials will not exceed his/her RUA inventory limits. Purchase and transfer requests for radioactive materials must receive an authorization from the Radiation Safety Information System (RSIS) prior to the order or transfer request being communicated to the supplier.
- maintaining compliance with the rules and precautions in the RSM and RUA;
- keeping radiation exposures ALARA; and
- informing the RSO of any unsafe conditions; and
- posting of RUAs and other required signs/forms.

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See Appendix D for details.

Proposed RHs must meet strict requirements. Deviations from these requirements must be reviewed and approved by the RSC.

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 in 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 dose is quantified and expressed

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- use of radiation-detection instrumentation
- biological hazards of exposures to the types, forms, and amounts of radiation sources to be used.

2.7 User

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A radiation “user” is any individual listed on an RUA. Users are responsible for their own safety and for the safety of those around them.

Specifically, each user is responsible for:

- ❑ successfully completing the radiological safety training and retraining required by the RSM and the RH for his/her specific RUA,
- ❑ keeping radiation exposures ALARA;
- ❑ maintaining compliance with the rules and precautions in the RSM and RUA;
- ❑ informing the RSO and/or the RH of any unsafe conditions.

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See appendix E for details.

2.8 Ancillary Personnel

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Ancillary personnel include workers (maintenance or other) who are assigned to perform work in areas listed in a RUA (often on a temporary basis), but who are not deliberately working with radioactive materials or RPMs. These workers must adhere to sections of the RSM that govern safety procedures and control of exposure to radiation. Such work assignments may be reviewed and controlled by the RH and/or the RSO. The RH is responsible for ensuring these workers receive radiation safety training commensurate with the potential radiological health protection problems in the controlled area.

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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 (see section 3.1.1, below). 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.

It is difficult to provide a set of requirements that covers the varied uses of radioactive materials and radiation on a large research campus. On occasion, complex situations encountered in research require the RSO to work closely with the CDPH to achieve a workable process that satisfies regulatory requirements.

Under normal circumstances, research is best served by allowing researchers flexibility to establish and implement their own safety requirements. Uses of ionizing radiation, however, have regulatory and operational restrictions that require formal approval, control, and inspection. The interests of individual and public safety dictate a stringent program to meet both safety and regulatory needs.

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. Copies of federal and state regulations, licenses, and UC Berkeley policies (found in this RSM) are available to RHs and users in several forms, including electronically on the EH&S website (<http://ehs.berkeley.edu/>). The RSO serves as the lead for the program documents, and for understanding and interpreting regulatory and campus requirements.

The Radiation Safety Program applies to all personnel under university auspices who use, supervise, or have access to radioactive materials or units that produce ionizing radiation, regardless of intensity or quantity. The requirements summarized in this section establish a minimum level for radiation control. Special needs may require individually tailored solutions.

3.1.1 Regulation of Radiation Use

Use of radioactive materials and RPMs is a privilege administered by CDPH that can be withheld much like a driver can lose his or her operating license.

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.

The NRC and CDPH regulations determine the basic rules and restrictions that apply to uses of radioactive materials and radiation at UC Berkeley. The regulations are intended to cover a broad range of radiation uses, one of which is university-level research. The CCR is binding for each person using a source of ionizing radiation, whether it be radiation from generally licensed material, specifically licensed material or radiation emitted by radiation producing machines. While RHs and users are not required to read the state regulations, they are responsible for adequate implementation of these regulations based on the information provided in this RSM, by user training, and from

specific information provided by the RSC and RSO.

It is important that all users recognize that if UC Berkeley fails to demonstrate reasonable compliance with state regulations (even if only in a single campus use by one user), the non-compliance can trigger state enforcement actions. In the most severe cases, non-compliance can result in termination of all UC Berkeley uses of radiation.

3.1.2 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).

Campus exemptions, if any, from state regulations are contained in the license issued to UC Berkeley by the state.

3.2 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.) any source of ionizing radiation.

Application for an RUA is made using forms available on the EH&S website (<http://ehs.berkeley.edu/>) or provided by EH&S. The application requires (1) a project description (the research protocol is normally adequate), and (2) a completed Radiation User Information Record that, among other things, describes the training and experience of user(s). A completed Radiation User Information Record must be submitted for each person listed on the RUA.

The radiation safety staff performs and documents an evaluation of 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 use. At the RSO’s discretion, complex uses may require review by the RSC.

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. Factors considered by reviewers in the approval process include:

- the extent of radiation hazard
- evaluation of safety provisions
- the experience and ability of the applicant and the users to cope with hazards involved in the particular application
- UC Berkeley radiation safety training and retraining status
- the adequacy of the facilities and equipment for the proposed use

- ❑ the thoroughness and attention given to safety precautions in the proposed experimental procedures and waste disposal.

The RUA specifies any special conditions related to the use (e.g., special precautions, modes of disposal, purchasing procedures, dosimetry, and/or survey meters). Once the RUA has been approved and signed, an electronic copy of the RUA is made available to the RH, and work involving radiation may begin. 3

Note: Certain types of radioactive materials require additional controls to satisfy state and federal requirements. The Radiation Safety Team will advise RHs (and RUA applicants) in cases where additional controls are necessary to satisfy regulatory requirements. How these controls will be satisfied must be described in the application and will become a condition in the RUA. For examples of cases where additional controls are required include: 3

- Possession or use of certain large radioactive sources (may be subject to either the National Source Tracking System or the UC Berkeley Increased Control Plan).
- Possession or use of special nuclear materials (must be controlled in accordance with Radiation Safety Procedure RP-20, “Working With Special Nuclear Materials” and inventoried in accordance with RP 74, “Inventory of Radioactive Materials”).

When a new RUA (or an amendment to an RUA) is requested for radioactive materials that require special controls, adequate information on how the applicable controls will be satisfied must be included in the application. Appropriate methods for complying with the special controls will become a condition of the RUA. 3

3.2.1 Application for Material or Machine Use

For an initial application, complete and submit the following forms, available on the EH&S website (<http://ehs.berkeley.edu/>):

- ❑ Radiation Use Authorization Application
- ❑ Standard Operating Procedures and/or Protocol
- ❑ Radiation User Information Record(s)

3.2.2 Application for Instructional Use

An RUA is required for any use of radiation or radiation sources in academic coursework or laboratories. Such RUAs are issued in the name of the instructor. Please provide the same information as in 3.2.1, above.

3.2.3 Application for Use of Radiation in Animals

In addition to the process described in 3.2.1 and 3.2.2, 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. See appendix G for more information. 3

3.2.4 Application for Use of Radiation in Human Research

If human subjects will be exposed to radiation, then both an RUA and approval by the Committee for the Protection of Human Subjects (CPHS) are required before exposure to radiation.

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See appendix G for more information.

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

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Each use of radiation or radioactive material in the field must be carefully considered and thoroughly reviewed to ensure compliance with all appropriate laws, regulations, and commitments. These reviews must be conducted before requesting an RUA and the safety analysis must demonstrate how compliance will be achieved.

Use of radiation or radioactive materials in the environment (field) at use locations specified in the Radioactive Material License (License Condition 10) require the RSO notify the CDPH at least 40 days prior to the first utilization.

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.

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Note: 10 CFR 51.22(c)(14)(v) identifies as a categorical exclusion (from the requirement to prepare an environmental assessment or impact statement) the use of radioactive material for research and development and for educational purposes. However, this categorical exclusion does not encompass, among other things, performance of field studies in which licensed material is deliberately released directly into the environment for purposes of the study (e.g., tagging of animals or insects that remain in the wild). These types of requests may require an environmental report filed by the applicant and an environmental assessment by NRC, pursuant to 10 CFR Part 51. Field studies that do not deliberately release radioactive material into the environment, such as tagging of animals and penning them to prevent escape, may be eligible for a categorical exclusion, pursuant to 10 CFR 51.22 (c)(14)(xvi).

If you desire to perform field studies in which licensed material is deliberately released to the environment for the purposes of studies, the requestor of the RUA must provide the following information:

1. A complete application describing the type and amount of material to be used, the location of use, and training and experience of the individual using the material.
2. A complete experimental protocol.
3. A description of the amount of radioactive material to be released in the field, decontamination procedures at the conclusion of the experiment, if appropriate, and procedures for minimizing releases.
4. A description of the expected radiation dose to humans.
5. Written permission from the property owner to use radioactive materials at the proposed site.
6. A letter from the appropriate state health authorities indicating that they have reviewed your application and concur with your request.

3.3 Review of RUA Applications

After the application for a RUA is submitted, the RSO reviews the materials and generates a RUA. Based on a variety of issues, the RSO determines the precautions necessary for use and the level of review required. In some cases, the RSC is involved in reviewing and approving the RUA. Details of the review and approval process are found in Appendix 5, "Radiation Use Authorization Process."

3.4 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 contacting the RSO or an EH&S RST staff member.

3.4.1 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.

3.4.2 Revisions

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

3.5 RUA Renewal

Periodically, Radiation Safety staff in EH&S review the RUA to determine the status of the use. If the project will continue beyond the expiration date, the RUA must be renewed. If a project is close to completion, a closeout survey will be scheduled. Section 3.8 describes the RUA termination process.

A RUA can be renewed for a period up to three years. If a RUA Holder does not use radioactive material or a RPM for more than one year, the RUA Holder may continue the RUA for one additional year without use of radioactive materials or a RPM. At the end of the second year, without use, the RUA Holder must either terminate the RUA, or be granted permission from the RSC to hold the RUA without use for one additional year. The RUA must be terminated within three years if it has not been utilized during that time period.

A RUA may be placed on hold at the request of the RH. The frequency of EH&S RST oversight surveys may be reduced. 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. The duration of the on hold status will be as described in the previous paragraph. (By placing an RUA on hold, the RH will likely qualify for a reduced service charge from EH&S).

3.6 Registration of Radiation-Producing Machines (RPMs)

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. 2

Sixty days prior to 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

The RSO must register the “reportable source” CDPH in accordance with 17 CCR § 30108. 3

3.7 EH&S Radiation Safety Surveys

The RST perform periodic surveys of areas in which radiation is used. The frequency of the surveys is based on a number of factors, such as perceived risk and past RUA compliance. The standard frequency of surveys is quarterly for Class III, semiannually for Class II, semiannually for Class I with unsealed radioactive material and annually for Class I (sealed radioactive material) and RPM RUAs (See Appendix 5 for definitions of Class). 3

The CDPH expects that no less than 50 percent of the surveys performed by EH&S staff will be performed “unannounced.” However, EH&S makes every effort not to disrupt ongoing research and will often reschedule a survey to meet the needs of a researcher. In cases where other EH&S hazards are present, the RST will comply with posted notification requirements prior to entering rooms or laboratories (i.e. animal use, laser and intense magnetic flux areas). 3

These surveys are performed to determine if operations are being conducted properly and safely. Specifically, EH&S surveys will include checking the following: 3

- Are the form and quantity of radioactive material present consistent with the limits on the RUA?
- Are radioisotopes 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 limited to appropriate areas for RUAs that authorize possession of unsealed radioactive material? 3
- Are laboratory procedures available and followed?
- Are required safety notifications posted and adequate?
- Does safety-notification labeling meet requirements?
- Are required records maintained and current?
- 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.

3.7.1 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 or apparent items of non-compliance, 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 placed with the EH&S records for the laboratory. 3

In the event of any single serious violation (equivalent to a NRC Severity Level 3 or higher), 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 RSO may request the RH to: 1. conduct a complete and thorough review of the circumstances that lead to the unacceptable situation; 2. identify the root and/or contributing causes that lead to the unacceptable situation; and 3. take prompt and comprehensive corrective action that will address the immediate concerns and prevent recurrence of similar unacceptable situations. The RH will be requested to respond in writing within 30 days 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. The RSO will provide copies of the written response to the RSC and will provide an analysis of the response including what factors the EH&S played in regard to implementation of the Radioactive Materials License conditions. 3

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. The RSC may request the RH appear before the RSC, it may request written confirmation of actions described by the RH to the RSC, and may solicit the assistance of the RH’s Chair and UC Berkeley executive management representatives prior to denying a researcher the opportunity to use radiation or radioactive materials in his/her research. 3

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) (other than stop work orders) 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 sufficiently in advance to permit scheduling of the closure survey of the use areas. The closure survey will include an accounting of radioisotope inventory and satisfaction of requirements for decontamination. The area cannot be released for other uses until this termination process has been completed. 3

Upon termination of the RUA, the accounting of all radioisotopes or acquired RPMs is made part of the termination survey. 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 HMRS for disposal. Contact 3

EH&S RST for specific termination instructions.

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 guidelines (See appendix F-12). 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. | 3

All remodeling to areas where radioactive materials had been used or stored must be coordinated with the EH&S RST. | 3

Permanent vacating of buildings or use locations specified in the license require prior approval of CDPH. This process may require years and considerable expense. 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. | 2, 3

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. The RSO may recommend consultation with competent medical representatives; the potentially exposed individual is expected to comply with that recommendation. | 3

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4 RADIATION EXPOSURE POLICY

4.1 ALARA (As Low As Reasonably Achievable) Policy

UC Berkeley has an aggressive policy to prevent unnecessary radiation exposures to persons and the environment, and to keep any exposures as low as reasonably achievable (ALARA). The ALARA protocol is defined in federal regulations (10 CFR 20.1003). ALARA attempts to maintain exposures to radiation as far below the dose limits as possible, 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)

Category of Dose Equivalent	Regulatory NRC/CDPH Limit ¹	UC Berkeley Administrative Guideline ²
Total Effective Dose Equivalent (TEDE)	5,000 mrem/yr	500 mrem/yr
(Eye) Lens Dose Equivalent (LDE)	15,000 mrem/yr	1,500 mrem/yr
Shallow Dose Equivalent (SDE): Skin or extremities (hands and forearms, feet and ankles)	50,000 mrem/yr	5,000 mrem/yr
Total Organ Dose Equivalent (TODE)	50,000 mrem/yr	5,000 mrem/yr
Minors (<18 years of age)	10% of NRC limit for adult workers	5% of UC Berkeley administrative guideline for adult workers

¹Regulatory limits are legal dose equivalent limits adopted by the NRC and/or CDPH.

²Administrative guidelines are dose equivalent recommendations adopted by the Radiation Safety Committee (RSC) for all UC Berkeley personnel. These guidelines should not be exceeded in routine operations without prior RSC approval. The administrative guidelines are not intended to be absolute limits, but to provide guidelines for keeping exposures ALARA.

No RH shall possess, use, or transfer sources of ionizing radiation in a manner that could expose anyone to an occupational dose higher than any of the above limits.

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*	UC Berkeley Administrative Guideline*
Annual limit/guideline for dose to any individual member of the public	100 mrem	10 mrem
Limit/guideline for dose to any individual member of the public in a single hour	2 mrem	0.2 mrem

* See note under table 1 on previous page.

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4.4 Prenatal Radiation Exposure Policy

UC Berkeley intends that instruction and training be “commensurate with potential concerns present in the workplace.” One of these concerns is for the unborn child of a pregnant worker.

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. Regulations require that UC Berkeley make every effort to avoid substantial variation above a uniform monthly exposure rate (described below).

4.4.1 Federal and State Regulations

Special federal and state 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: <http://ehs.berkeley.edu/radsafety/forms.html>.

3

Unknown
Field Code Changed

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 NRC sets specific dose limits for the embryo or fetus of a declared pregnant worker. The dose to the embryo or fetus during the entire pregnancy 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.

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

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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 (<http://ehs.berkeley.edu/>). Additionally, the campus RSO (contact information is on the website) is available to answer any questions users may have. All inquiries and information are kept strictly confidential.

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Additional information is provided in Appendix I, “Special Information for Pregnant Workers.”

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4.5 External Radiation Dose

4.5.1 Requirements

Federal law requires that personnel exposure monitoring be provided if a person is likely to receive radiation doses in excess of 10 percent of CDPH limits. Dosimetry is also required for individuals entering an area of “high” or “very high” radiation (defined in Appendix J).

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 is required and will be provided by the RST Dosimetry Coordinator.

4.5.3 Obtaining Initial Dosimeters or Temporary Replacement Dosimeters

Please contact EH&S and request to have the RST Dosimetry Coordinator contact you to arrange a time when you can come to the EH&S office to pick up the needed dosimeter(s). The Dosimetry Coordinator will provide a form (or direct you to the applicable URL to download the form). You will need to submit this form at the time you pick up the dosimeter(s). If it is likely that the person will receive an annual dose in excess of the Table 1 guidelines then the RSO will request an estimate of the dose received during the current year and attempt to obtain records of the persons cumulative occupational radiation dose.

4.5.4 Proper Use of Dosimeters

All users of external dosimeters should follow these guidelines:

- ❑ 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 on the palm side of the finger. The RUA will provide any special wear or placement requirements.
- ❑ Never intentionally expose a dosimeter to radiation other than the radiation exposure it receives while being properly worn during your RUA activities. (If you are curious about how the dosimeters work and how they are tested, please contact EH&S for information.)

- ❑ Store dosimeters away from sources of radiation and environmental extremes (e.g., extreme moisture or extreme heat). DO NOT store the dosimeters inside any sort of special shielding. In order to correctly assess a person's dose from sources of radiation used during RUA activities, the dosimeter must be recording the ambient natural background radiation at all times.
- ❑ 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.
- ❑ If planning to do radiation work at any location that is not listed on your UC Berkeley RUA (for example, work at a DOE site), please check with EH&S about the planned work and appropriate dosimetry arrangements.
- ❑ 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).
- ❑ If a dosimeter was in carry-on or checked luggage during an airline trip, please notify EH&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 (and each use under an 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.

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 high quantities of radioiodine, and (2) urine assays, for other isotopes. Other methods may be used when appropriate.

The RSO or RSC determines the need for bioassays and notes the requirement on the RUA. Typically, bioassay programs are aimed at individuals who use dispersible materials or work in the vicinity of materials being used that could result in a dose greater than 10 percent of CDPH limits.

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. Two specific conditions require review for accuracy and cause:

- Whole-body doses registering 100 mrem or more (≥ 100 mrem) in a dosimetry reporting period (typically a period of 4 months), and
- Extremity doses registering ≥ 500 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 (see section 4.2, Tables 1 and 2) 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. The investigation results are reviewed by the RSC.

4.7.3 Overexposures

UC Berkeley Administrative Limits

The RSO investigates any exposures above the UC Berkeley administrative guideline value.

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 measurable 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. Since the RH is the line manager responsible for all activities associated with use of his/her radioactive materials or RPM, the request to list someone on the RUA must originate with the RH.

The RH will decide the level of supervision necessary for each of his/her authorized users.

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. Please contact EH&S to request additional information.

5.2 Training

Radiation workers must be trained in the hazards they may encounter on the job and in methods to protect them and minimize exposures. The content of training programs for handling and safely using radiation sources is specified by the RSC.

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 the applicable types of 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 listed on an RUA may be obtained from a member of the EH&S RST. (It is also available at <http://ehs.berkeley.edu/radsafety/forms.html>).
- ❑ 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 radiation-producing machines. Most prospective users will be required to attend one of EH&S' periodically-scheduled in-person initial radiation safety training sessions.

Depending on the type of radiation use planned, some initial radiation safety training may require successful completion of an online training course and/or completion of a course conducted by an outside vendor and/or other special training specified by EH&S.

- ❑ For class work and specialized instruction, the RH or EH&S may provide read and sign training materials appropriate to the extent of radiological hazards present during the instructional experience. For example, the NE 104 course includes reading assignments covering the RSM and instruction appropriate to the handling of radioactive material sources. The instructions must always cover at least the subjects required pursuant to 17 CA ADC 30255 (b). The training must be documented and the RH is responsible to insure only those individual completing the training

agreed on 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.

- The in-person initial training provided by EH&S will cover:
 - How to post areas where radioactive materials are stored or used.
 - How to post areas 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.
 - How to conduct and file surveys of workplaces where ionizing radiation work is performed.
 - How to keep work areas free of contamination.
 - How 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 radioisotope or radiation beyond the confines of the authorized work areas.

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. To request that such permission be granted, the RH must document that the person has received the instructions stipulated in California Administrative Code title 17, § 30255 (b). The RH can provide such training and submit a document, providing the name(s) of the individual(s), the planned date(s) of use, the name of the person providing the training and the following statement:

By submitting this request, I _____ am requesting that
(name of RUA Holder)

(list name[s] of proposed User[s])

be permitted to use a radiation source under my RUA during the following period: _____.

(date[s])

I confirm that, if approved, the individual(s) who is/are the subjects of this request, will only perform radiation work when I (the RUA Holder) am physically present and directly supervising that work. I also confirm that _____ has:

(RUA Holder or other qualified individual)

- informed this/these individual/s working in or frequenting any portion of this laboratory of the storage, transfer, or use of radioactive materials or of radiation in such portions of the laboratory,
- instructed such individual/s in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed,
- instructed such individual/s in, and instruct them to observe, to the extent within his / her control, the applicable provisions of the regulations and license conditions for the protection of personnel from exposures to radiation or radioactive materials occurring in the laboratory,
- instructed such individuals of their responsibility to report promptly to the RSO any condition which may lead to or cause a violation of the regulations or license conditions or unnecessary exposure to radiation or radioactive material, and of the inspection provisions of Section 30254,
- instructed such individual/s in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive materials,
- and advised such individuals as to the radiation exposure reports which they may request pursuant to this section. The extent of these instructions was commensurate with potential radiological health protection problems in the controlled area.

The RH providing the instructions and the individual(s) must sign and date the statement and mail (or FAX) a copy to the RSO for approval and filing in the RUA records.

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 Annual Refresher Training

As required by UC Berkeley's license, all active RHs and users must complete radiation safety refresher training each year. EH&S RST will provide a refresher training course each year; it will review radiation safety requirements, address new issues and identify ways to reduce dose and improve performance. The training will generally address use of radioactive materials and radiation producing machines in separate modules.

With exception of very low risk activities like use of electron microscopes, exempt quantities and some generally licensed materials, failing to complete annual 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 annual retraining as required.

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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.

Alternatively, the RH may provide ancillary personnel with a copy of the "Radiation Safety Guidelines for Non-Users" along with instructions specific to the RUA. (The guidelines are available in the training section of <http://ehs.berkeley.edu/radsafety.html>.)

The RH should provide retraining as necessary to ensure that persons granted access to the laboratory, but not authorized to enter or perform activities within the restricted area, are instructed in the radiological risks present in the laboratory, the actions they should take in response to an emergency, how they should minimize their own exposure and how they can contact the Radiation Safety Officer if they have questions.

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

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6 RECORD KEEPING

6.1 RUA Holder — Maintained Records

Records are required by state regulations. RHs must maintain records related to the uses of radiation specified in their RUAs. These records should form part of every Radiation Safety Laboratory Logbook, and must be available for review by EH&S and state inspectors.

Laboratory-maintained records include the following:

- ❑ A copy of the current RUA, which lists any specific requirements or conditions of use,
- ❑ A copy of this RSM. The manual must also be available to all authorized users, (Access to the online version or other electronic copies is acceptable)
- ❑ A copy of the RUA Standard Operating Procedures (SOP) or research protocol; see Appendix F,
- ❑ Copies of RUA surveys provided by the EH&S RST,
- ❑ Documentation of all radiation safety related training and attendance,
- ❑ Updated RSIS detailing:
 - a. each receipt of an isotope, its chemical and/or physical form, the quantity, and the date of receipt (including any radioactive materials transferred from one RUA to another),
 - b. the date, activity, and use of each withdrawal from stock.
 - c. disposal records documenting the date, activity, physical form, and method of disposal of isotopes and contaminated lab material.
 - d. current inventory of radioactive materials on hand.
- ❑ Records of laboratory self surveys and any corrective action taken.
- ❑ Other information as noted on the project's RUA.

Records maintained pursuant to this section may be the original or a reproduced copy or microform if the copy or microform is authenticated by the authorized user and the microform is capable of producing a clear and legible copy after storage for the period of time specified in the regulations.

7 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 and life-threatening situations typically 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) before being allowed to leave.

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 of radioactive materials or radiation-producing machines (RPMs)

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

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

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If the spill is significant, the RSO will help plan/coordinate the cleanup.

7.1 Personnel Contamination

In the case of personnel contamination, immediately call or have someone call EH&S (642-3073) to ensure that the RSO is notified. During off hours, call **911** 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.
3. For skin contamination, follow these decontamination procedures:
 - a. Wash the contaminated area for two (2) minutes using a mild soap and lukewarm water. Pay particular attention to areas between fingers and around fingernails. Do not 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. If soap and water removes some but not all, of the contamination, repeat steps a. and b. above up to three times. The RSO may recommend additional or specialized decontamination efforts. Stop decontamination efforts if the skin starts to turn red. Stop if washing is no longer reducing the level of contamination.

Note: Special contamination issues (eyes, nose, mouth, ears, wounds) are coordinated by the RSO and medical staff.

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

7.2 Procedures for Major Spills

1. Notify everyone not involved in the spill to leave the immediate area but assemble nearby.
2. Call or have someone call EH&S RST (642-3073). During off hours, call 911 (**642-3333 by cell phone**) and ask for radiation safety assistance.
3. Assess everyone who could possibly have been contaminated. See section 7.1, above, for information on how to deal with skin contamination.
4. Once potentially contaminated persons have been surveyed and found free of contamination, record their names and release them. These actions will greatly diminish the spread of radioactive contamination.
5. When feasible, use reasonable effort to confine contamination.
6. 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.
7. 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.
8. Do not allow work to resume in the area until approved by the RSO.
9. Place contaminated clothing and materials in bags labeled with contents, isotope, and date. EH&S will provide instructions on decontamination or disposal.
10. Record the event in the Radiation Safety Laboratory Logbook. (See Appendix J, "Glossary of Terms".)

7.3 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 (generally, only those needed to deal with the spill).
3. Put on personal protective equipment (PPE) as necessary.
4. Call EH&S (642-3073). During off-hours, call **911 (642-3333 by cell phone)** and ask for radiation safety assistance. | 3
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.”
11. Record the event in the Radiation Safety Laboratory Logbook.

7.4 Procedures for Radiation Producing Machine (RPM) Accidents

1. TURN OFF MACHINE. If possible, de-energize circuit breakers.
2. Call or have someone call EH&S RST (642-3073). During off-hours, call 911 and ask for radiation safety assistance. | 3
3. Treat medical problems first and administer first aid as appropriate. Treatment of injuries takes precedence over radiation exposure.
4. Notify the RH and others in the area.
5. 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 immediately notified and will initiate consultation with competent medical representative to assess dose and ensure proper medical follow-up. The RSO must also immediately report significant exposures to the CDPH. | 3

APPENDIX A

Overview: Radiation Safety Committee (RSC)

The RSC works with Executive Management and the RSO to establish UC Berkeley policies and procedures on radiation safety (see Appendix 2 for details). The committee is appointed by the Chancellor (or the Chancellor's designee) and advises the Chancellor, Vice Chancellor for Research (VCR), the Office of Environment, Health & Safety (EH&S), and others on radiation-safety issues. The RSC meets as often as required (but no less than once each calendar quarter) to review radiation program activities and other matters related to the committee's charge.

The RSC must act in the best interests of radiation safety, and has the authority to terminate a Radiation Use Authorization (RUA) if warranted. Where non compliance is identified, the RSC is charged with reviewing and either approving corrective actions already being implemented and/or taking actions including analysis of the cause, corrective actions, and actions to prevent recurrence.

A full description of the duties and bylaws of the RSC are available upon request from EH&S. If you want additional information as to the RSC responsibilities, refer to Appendix 2.

APPENDIX B

Overview: Office of Environment, Health & Safety (EH&S)

The staff of EH&S Radiation Safety Team (RST) implement the campus radiation-safety monitoring and use program. Specifically, this appendix provides additional information to Section 2.4 of the *Radiation Safety Manual*. EH&S RST does the following: | 3

- ❑ Provides general inspection of all campus activities that involve the use of radioactive materials and/or radiation producing machines.
- ❑ Provides guidance and services to UC Berkeley personnel at all levels on all aspects of radiation protection.
- ❑ Receives and inspects radioisotope shipments to UC Berkeley and ships all radioisotope packages that leave campus.
- ❑ Inspects all radiation-producing machines (RPMs) at least annually, and more often as requested or needed.
- ❑ Provides a personnel monitoring service (as required), maintains records of internal and external personnel exposure, and reports exposure issues to the Radiation Safety Officer (RSO) and Radiation Safety Committee (RSC) as appropriate.
- ❑ Notifies individuals, their supervisors, and the RSO of doses approaching or exceeding the UC Berkeley administrative guidelines, and recommends appropriate remedial action.
- ❑ Assists with the training of support staff, personnel who frequent radiation/radioactive-use areas, and personnel who use radioactive materials.
- ❑ Manages the radioactive waste program (including pickup, storage, and disposal records).
- ❑ Performs sealed-source leak tests.
- ❑ Maintains an inventory of all licensed radioactive materials located at UC Berkeley and associated facilities. | 3
- ❑ Supervises decontamination efforts.
- ❑ Prepares new Radiation Use Authorizations (RUAs) and amendments for review by the RSO.

-
- ❑ Performs bioassays.
 - ❑ Calibrates survey meters.

APPENDIX C

Overview: Radiation Safety Officer (RSO)

This appendix provides additional information to Section 2.4.3 of the *Radiation Safety Manual*. The RSO is a member of the Radiation Safety Committee (RSC), and is the individual responsible for all campus uses of ionizing radiation, radioactive materials, and radiation-producing machines (RPMs). The RSO's overall responsibilities include:

- ❑ Ensuring that radiation uses are in conformance with UC Berkeley standards and with applicable government regulations.
- ❑ Referring to the RSC matters requiring its review and approval.
- ❑ Ensuring that exposure to radiation used at UC Berkeley (to both on- and off-campus personnel and to members of the public) is as low as reasonably achievable (ALARA).

The RSO is a staff member of the Office of Environment, Health & Safety (EH&S), and provides updates, program status, and information to the RSC. The RSO obtains technical direction from and receives information from the RSC regarding campus radiation-safety policy. The RSO is held responsible for the campus Radiation Safety Program under the laws of the State of California, the UC Berkeley Radioactive Materials License, and the rules and policies set by the RSC.

C-1 Radiation Incidents

The RSO is to be notified of every actual or suspected radiation incident, including personnel exposure, workplace contamination, or loss or theft of radioactive material or radiation machine. Any overexposed dosimeter is considered presumptive evidence of exposure to the individual to whom the dosimeter was assigned.

The RSO classifies each radiation incident as "major" or "minor." Major incidents are those that require reporting to a regulatory agency. Minor incidents are generally only reported to the RSC; others are notified at the discretion of the committee or the RSO. For each occurrence, the RSO prepares a comprehensive incident report and sends copies to the individual(s) involved, the Authorized User (RH), the associated Department Chair or Unit Director, and the RSC.

C-2 Stop-Work Authorization

The RSO is empowered to halt any operations using radioactive materials or radiation that pose an immediate danger to the health or safety of the public and/or workers. If the RSC Chair or another 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 if and when an emergency meeting of the RSC should be held to review the stop-work order.

A more complete description of the duties of the RSO is available upon request from EH&S. If you want additional information as to the duties of the RSO, please see Appendix 8.

APPENDIX D

Responsibilities of the RUA Holder (RH)

This appendix provides additional information to Section 2.7 of the *Radiation Safety Manual*. With rare exceptions that require the approval of the Radiation Safety Officer (RSO) or RSC, all prospective RHs must:

- ❑ be employed by the University of California Berkeley and have line management authority to manage all resources and individuals authorized to use radioactive materials and radiation producing machines pursuant to the Radiation Use Authorization (RUA) 3
- ❑ possess a college degree or equivalent experience in the physical or biological sciences or in engineering;
- ❑ have training and/or practical experience in:
 - characteristics of ionizing radiation and its radiation-dose quantities;
 - use and care of radiation-detection instrumentation; and
 - biological hazards of exposures to the types, forms, and amounts of radiation sources to be used.

Each RH is responsible for compliance with federal, state, local, and campus regulations governing the authorized use of radiation. Specific responsibilities of the RH include:

- ❑ Applying for authorization to use sources of ionizing radiation.
- ❑ Complying with all conditions of the Radiation Use Authorization (RUA) and this Radiation Safety Manual (RSM).
- ❑ Preparing a plan before an experiment is conducted, to determine the types and amounts of radiation or radioactive material needed and the level of protection believed to be required.
- ❑ Performing a dry run for unfamiliar processes to identify unforeseen problems. If problems are encountered, the RH must contact the RSO before initiating the procedure.
 - radiation workers under the RH's jurisdiction; 3
 - training of ancillary personnel who may frequent the lab;
 - receipt, use, and disposal of radioisotopes; and
 - monitoring of laboratories and workplaces, including contamination levels and exposure data.
- ❑ Maintaining ongoing custody and security of any radioactive material or radiation-producing machines (RPMs) under the RUA. 3
- ❑ Updating the Radiation Safety Information System (RSIS)
- ❑ Having required records available for review by EH&S RST or any regulatory agency.
- ❑ Notifying the RSO of a proposed RUA termination sufficiently ahead of time (at least one week) to permit scheduling of termination procedures, including:
 - termination survey; 3
 - return of personnel dosimeters, bioassay samples;
 - removal of radiation-hazard warning signs;

- removal of radioactive waste;
 - removal or transfer of radioactive materials.
- Training supervised personnel. This training must include the following:
- A. Materials to read:
- The appropriate RUAs;
 - Pertinent laboratory instructions;
 - The “State Notice to Employees: Standards for Protection Against Radiation;”
 - The UC Berkeley RSM; and
 - Procedures for the control of radiation hazards and for limiting exposure to others according to the type of radiation sources used.
- B. Completion of EH&S-provided radiation safety training and annual retraining described in Section 5.5 of this manual.

3

APPENDIX E

Responsibilities of RUA “Users”

This appendix provides additional information to Section 2.8 of the *Radiation Safety Manual*. 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.
- ❑ Ensure that training and safety equipment are adequate. Check with the RUA Holder (RH) or Radiation Safety Officer (RSO) if there are any questions.
- ❑ Keep exposure to radiation as low as reasonably achievable (ALARA).
- ❑ Minimize airborne radioactive contamination.
- ❑ Wear required personal protective equipment (PPE).
- ❑ Wear dosimetry and/or participate in the bioassay program if required | 3
- ❑ Inform the RH and/or RSO of any unsafe conditions.
- ❑ Implement radiation-control techniques.
- ❑ Separate radiation work and storage areas from areas of non-use.
- ❑ Keep personal items away from laboratory or use areas.
- ❑ Never eat, drink, smoke, or apply cosmetics in the laboratory within three feet of an area where unsealed radioactive materials are present. | 2
- ❑ Cover all work areas with absorbent paper as a protection against spillage.
- ❑ Use shielding as needed.
- ❑ Place waste materials in appropriate, labeled containers.
- ❑ Maintain good housekeeping in the laboratory.
- ❑ Protect against personal contamination by (a) wearing gloves and using tongs, (b) using remote pipetting techniques, (c) taking frequent surveys, (d) not working if they have an open skin wound, and (e) wearing laboratory clothes over street clothes.
- ❑ Clearly mark all contaminated glassware or equipment.
- ❑ Use fume hoods for volatile materials.
- ❑ Update the Radiation Safety Information System (RSIS) | 3
- ❑ Label work areas, materials, and/or containers as required.
- ❑ Learn what instruments to use for effective monitoring, and how to use them.
- ❑ Survey equipment and work areas to find and control contamination.
- ❑ If contamination is suspected, check with a suitable survey meter or by means of an “area wipe.” Decontaminate if necessary.
- ❑ Wash their hands and check themselves for contamination before leaving the laboratory, using a suitable survey meter.
- ❑ Document all contamination and elevated dose rates. | 3

APPENDIX F

Laboratory Standard Operating Procedures (SOP)

Everyone who uses radioactive materials or radiation-producing equipment is responsible for ensuring that personnel radiation exposures are kept as low as reasonably achievable (ALARA). This section includes standard laboratory requirements and procedures to accomplish this. The Radiation Use Authorization (RUA) may prescribe additional specific precautions and conditions.

F-1 Procurement Procedures

Obtain prior approval using the Radiation Safety Information System (RSIS) before procuring radioactive materials or radiation-producing equipment, 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. Please be aware of your RUA limits and verify the RSIS reflects your current inventory when ordering, so that receipt of your order is not delayed.

3

F-2 Transferring Radioactive Material

Contact the Radiation Safety Officer (RSO) before transferring any radioactive material between RUAs. Both the transferor and the recipient must record the applicable changes in their RUA radioactive materials inventories on the RSIS.

3

Off-campus transfers are governed by federal and state regulations; such transfers must be made through EH&S RST.

3

F-3 Receiving Radioactive Material

All radioisotope shipments are delivered by the carrier to EH&S. EH&S RST inspects each package for the following:

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

3

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 radioisotope receipts.

3

Prior arrangements must be made for shipments that will not conform to the procedures described above such as the acquisition of laboratory containing a generally licensed radioactive source or a RPM at a specific laboratory.

3

F-4 Security of Radioactive Material

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

Rooms containing radioactive material or 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 material or RPM. If the room is unlocked and non RUA authorized users are permitted to be in the room, then the radioactive material or RPMs must be either under constant surveillance by RUA personnel or locked such that it cannot be used, operated or removed by an unauthorized individual.

F-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 at <http://campuspol.chance.berkeley.edu>). 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.

F-6 Inventory Control and Possession Limit

RHs must keep records and inventories of all radioactive materials under their control. Each record must include isotope, quantity (in millicuries), activity, date, and storage location. The computer program called the Radiation Safety Information System (RSIS) must be used for this purpose. RH may keep additional records however these records must be retained until they are provided to EH&S RST at the time of RUA termination.

For unsealed sources, the inventory records should also include sufficient information to help locate the materials. This may include:

- How much activity is in the original container.
- How much has been transferred to another container (in solution, for example).
- How much is in process (active use).
- How much is in waste.

The RH must ensure periodic audits are conducted and documented to visually verify the locations of all unsealed radioactive materials and semiannual inventory of all sealed sources. This may be coordinated with the RST semiannual leak tests of sealed radioactive sources or annual verifications of source and special nuclear materials. In all cases a record of the inventory audit must be made and preserved. Missing radioactive material must immediately be reported to the RST. The RST will consult with the RSO to ensure CDPH is informed, as required). All sealed radioactive sources must be inventoried at least semiannually and leak tested by the RST semiannually except in such cases where CDPH regulations or a license condition specifically exempts a particular source from the leak test and/or inventory requirement.

3

Note: 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.

2, 3

F-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:

3

- The “Notice to Employees” form (RH-2364). This sign outlines specific rights to fair and safe treatment of radiation workers, and must be posted at appropriate locations as required by Title 17 CCR, §30255. This notice is normally posted by EH&S Radiation Safety at a central location(s) for each building. It is also available at <http://ehs.berkeley.edu>. This “Notice” must be reposted anytime the CDPH changes its form.
- Standard laboratory operating procedures (SOP) for RPMs and a copy of the RADIOISOTOPE SAFETY & EMERGENCY PROCEDURES provided by EH&S RST for radioactive material users.
- Emergency laboratory contacts and phone numbers.
- Note: The RUA does not have to be a signed copy; however, it must be the currently approved version and be posted in all use locations, i.e. rooms listed on the RUA.

2, 3

In addition:

- If you store or use radioisotopes, post all entrances with a sign bearing the radiation caution symbol and the words, “**CAUTION: RADIOACTIVE MATERIAL(S).**”
- If you have accessible areas in which radiation levels could result in a dose equivalent exceeding five mrem in one hour at 30 centimeters from the radiation source or from any

surface that the radiation penetrates, they must be posted with the words “**CAUTION: RADIATION AREA.**”

- Radiation Producing Machine Sign

Note: These signs are available from EH&S.

3

F-8 Labeling Requirements

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.

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.

Work areas

All work areas used in radioisotope procedures (including tabletops, equipment, and storage areas such as refrigerators) must be labeled. A good labeling method is to use “Radioactive Material” (RAM) tape when securing absorbent paper in work areas. At least one bench or area label must contain a radiation symbol (trefoil) with text that reads, “Caution: Radioactive Material” and identifies the isotope being used.

Sealed sources

Unless impractical, label the source, its shield, or the apparatus in which the source is mounted with a permanent radiation warning sign.

Requirement for Removal of Labeling and Posting

Radiation labels and posting must be removed, defaced or documentation provided to indicate the room or container no longer has radioactive material present. For example, a labeled box used to ship radioactive material must be surveyed to verify the absence of radioactive material and contamination before it is disposed of in “clean” trash. The radioactive material label should be removed but, at a minimum, it must be defaced before it is placed in the clean trash.

3

F-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, (2) the external radiation exposure hazard, (3) the complexity of procedures, and (4) the physical and chemical characteristics of the material used. Specific controls are noted on each RUA.

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), (i.e. safety glasses, face shield, gloves, lab-coats) and perform contaminates surveys frequently.

3

Note: Consumption of food and drink is not allowed in laboratories; however, the RH may allow consumption in designated controlled areas of the laboratory. The establishment of any designated clean area within such a room requires the RH to obtain formal written approval of the chair of the campus Radiation Safety Committee (RSC).

3

When designated clean areas must be located in the same room as unsealed radioactive materials, the clean areas must be located as far as feasible, but no less than one meter, from the “restricted area” where radioactive material is used or stored. If the designated clean area must be contiguous with the “restricted area” (such as on the same bench top), a substantial barrier must be obtained by the RUA Holder and placed to separate the radioactive material from the designated clean area. Details are available by contacting the EH&S RST.

3

Each clean area must be clearly demarcated around its perimeter with blue adhesive-backed tape at least one-half inch wide, and affixed with at least one adhesive-backed sign (available from EH&S) reading as follows:

NOTICE
CLEAN AREA

FOOD OR BEVERAGES ALLOWED ONLY IN THIS AREA

PROHIBITED IN THIS AREA:

- Hazardous Chemicals
- Biological Hazards
- Human Blood or Tissues
- Research Animals
- Radioactive Materials not permitted within one meter of this area

WASH UP

Ensure you are not contaminated before eating or drinking.

2

External exposure control

Requirements for shielding and/or remote-handling devices depend on the external radiation levels of the specific radioisotopes and the amounts to be handled. Specific requirements are established by the RSO or the RSC. Generally speaking, the following applies:

In Controlled Areas

Experimental setups and storage operations should be designed so that the laboratory dose rate, measured at 30 centimeters from any unshielded source or shielded enclosure, is very low. Suggested design guidelines set maximum dose rates of:

- 0.2 millirem per hour **deep-dose** equivalent rate
- 0.5 millirem per hour **lens-dose** equivalent rate
- 2.0 millirems per hour **shallow-dose** equivalent rate

In Unrestricted Areas

Deep-, lens-, and shallow-dose equivalent rates at five centimeters from the boundaries of any adjacent controlled area should be less than 0.2 millirems in any one hour. Total effective dose equivalent (TEDE) to any member of the public should be less than 10 mrem in any one year.

3

F-10 Overview: General Radiation-Control Techniques

The following are general procedures for radiation control in a radioisotope laboratory. With slight modifications, these procedures can satisfy most needs.

- Do not bring personal belongings, other than those required for work, into the laboratory.
- Separate radiation work and storage areas from general personnel spaces.

- ❑ Do not eat, drink, smoke, or apply cosmetics in the laboratory within three feet of any area where unsealed radioactive materials are present. | 2
- ❑ Cover work areas with absorbent paper to protect against spills.
- ❑ Use appropriate shielding.
- ❑ Put waste materials in appropriate containers.
- ❑ Maintain good housekeeping in the laboratory.
- ❑ Restrict public access.
- ❑ 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 (i.e. fire resistant clothing if working with flammable materials). | 3
- ❑ 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.
- ❑ Periodically check gloves, forearms and other PPE for contamination. | 3
- ❑ 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.
- ❑ Use appropriate laboratory facilities and equipment.

Additional requirements for “high” and “very high” radiotoxicity nuclides

If you will be working with nuclides with high or very high radiotoxicity, as defined in Appendix 5, the RUA will note that. You should consider the following: | 2

- ❑ Pre-plan the operation in detail and consult with the RST. | 3
- ❑ Decide on actions required in case of emergencies.
- ❑ 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.
- ❑ Routinely monitor all areas and operations.

F-11 Laboratory and RPM Self-Surveys/Checks

3

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 1 below lists methods and instruments recommended for detection or measurement of radioactive materials. Generally, instruments capable of measuring dose rates will be required if an unshielded radiation source (sealed or unsealed radioactive material or RPM) possessed by the RUA will produce a dose rate of greater than 2 mr/hr at 30 cm from the source.

3

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	< 200 KeV	H-3, C-14, S-35	Wipe—LSC
	≥ 200 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 NaI scintillation Wipe—LSC Energy compensated GM Ion Chamber
	≥ 200 KeV	Na-22, I-131, Cr-51 Cs-137, Ra-226	Thick NaI scintillation Wipe—LSC Calibrated GM Ion chamber Solid state detectors
Neutron	all	PuBe, AmBe accelerators	Proportional counter

3

Survey Frequency

EH&S will specify the frequency and type(s) of user surveys and indicate this on the RUA form. In the case of radioactive materials use, the required self-survey type(s) and frequency will be based on a variety of factors, including the Hazard Guide Value (HGV), the particulars of the use, and the professional judgment of the RSO. The following tables provide the RSO with general guidance, but the RSO's judgment and the laboratory's past performance play more important roles in determining self-survey frequency.

3

Table 4. Typical User Self-Survey Frequency, Based on the RUA's HGV

Area	Monthly	Weekly	Daily
Controlled	<10	10–1,000	>1,000
Restricted	<100	100–10,000	>10,000

Table 5. Typical User Self-Survey Frequency, Based Relative Radiotoxicity and Radioactive Materials Use Rate

Relative Radiotoxicity	Monthly	Weekly	Daily
4 – Very High	<10 µCi	10 µCi–1 mCi	>1 mCi
3 – High	<100 µCi	100 µCi–10 mCi	>10 mCi
2 – Moderate	<1 mCi	1 mCi–100 mCi	>100 mCi
1 – Low	<10 mCi	10 mCi–1,000 mCi	>1 Ci

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.
- ❑ Drawing of surveyed area, with identifying relevant features such as active storage areas and active waste areas.
- ❑ Measured exposure rates and/or contamination levels, keyed to location on a drawing of the area. If contamination levels exceed twice background of the measurement instrument used, the activity should be documented in units of either microcuries or disintegrations per minute. Dose rate should be recorded in mrem/hr.
- ❑ Corrective action taken, if contamination or excessive exposure rates were found, and the reduced levels after corrective action.

Periodic surveys for radiation leakage and tests of interlock and power/shutter status indicators are required for many RPMs. Where required, RHs must maintain permanent written records of such surveys and tests. Details of such requirements will be indicated on the RUA form that applies to the RPM.

F-12 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 gross or personal contamination. 3

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.
- ❑ Carefully remove all loose or easily removable contamination, then wash with soap, detergent, or special solvents.
- ❑ Place used cleaning materials (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. 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.

NOTE: 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. In addition disposal of refrigerators must comply with the information provided at: <http://businessservices.berkeley.edu/overstock/disposal/refrigerators>.

Hazardous and radioactive materials cannot be sent to Overstock for release to the public. Please see: <http://businessservices.berkeley.edu/overstock/disposal/hazardous>.

Contact the RST for questions related to disposal of radioactive material. 3

Workplace surfaces and floors that cannot be decontaminated to acceptable levels must be (1) treated to fix the radioactivity in place, or (2) shielded to bring exposure to an acceptable level, or (3) isolated to allow for radioactive decay, or (4) removed and disposed of as radioactive waste. The decision and action taken must be documented, the affected area labeled, and access restricted as needed.

Levels of contamination on skin, clothing, 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.

Table 6. UC Berkeley Contamination Limits

(Adapted from table 2 in United States Nuclear Regulatory Guide 8.23, January 1981.)

	Total (Includes removable and fixed contamination)			
TYPE OF SURFACE	dpm/100cm²	α emitters dpm/100cm²	β, X or γ emitters Radiotoxicity level 3, and 4 dpm/100cm²	β, X or γ emitters Radiotoxicity level 1 and 2 dpm/100cm²
Restricted and Controlled Areas				
Within posted radioactive materials zones	1,000 α 10,000 β, X or γ	200	2,000	10,000
Outside posted radioactive materials zones	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 contamination survey instrument			
Unrestricted Areas¹				
All surfaces, including items removed from restricted and controlled areas and "trash"	Not statistically different from background* ²			

*Background radiation is ambient radiation from the cosmos, from rocks and soil, or from ⁴⁰K (radioactive potassium) in the body.

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

¹Note: Contamination found in unrestricted areas should be promptly decontaminated to background levels. In no case should contamination levels in excess of twice background, or the limits presented in Table S.5 *Acceptable Surface Contamination Levels* of NUREG 1556 Volume 11, be permitted. Demonstrating compliance with the levels in Table S.5 require consideration of the instrument being used, the level of background in the area, the duration of the background and contamination measurement, the collection efficiency of the media being use to determine the removable contamination, and the efficiency of the measurement instrument for the isotopes being measured.

²Note: For the release of material, equipment, or laboratory facilities used with unsealed radioactive material and activation potential, surveys must be performed and documented that demonstrate the limits presented in USNRC Regulatory Guide 1.86

could have been detected and the “as found” level of residual contamination was not detectable. Any detectable contamination, although less than the Regulatory Guide 1.86 levels, should be decontaminated before unrestricted release. The RST should be consulted for assistance in this area.

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F-13 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. Each RUA details the project limit for drain disposal of aqueous liquids containing radioactive materials to the sanitary sewer. Radioactive materials on an RUA may not be released into the air or disposed of in the regular trash.

The Radiation Safety Logbook contains information about packaging, labeling, segregation, and EH&S pickup of radioactive wastes. General guidelines are provided by type of waste, below.

Mixed waste

A mixed waste is a radioactive hazardous waste containing hazardous chemicals. (One example of mixed chemical and radioactive waste would be a container of acetone combined with radioactive material.) Mixed waste must be treated separately from other waste. Label waste carefully, listing any known hazardous constituent, and contact EH&S. Mixed waste presents unique problems for disposal; avoid generating mixed waste whenever possible. The RSO can offer guidance on ways to minimize or eliminate mixed waste.

Mixing isotopes

When possible, isotopes should not be mixed. Waste that combines two or more isotopes presents special problems. Each isotope has a different half-life (“decays” at different rates). While it may be possible to hold some waste for decay and dispose of it as non-radioactive, this cannot be done if short half-life waste is mixed with long half-life waste. An example would be the combination of P32 (half life of about two weeks) and H3 (half-life of about 11 years).

Waste disposal

- ❑ When disposing of radioactive waste, recognize that other hazards (biohazards, chemicals, sharps, etc.) may be present, and that each must be managed appropriately. Consult EH&S for assistance, if needed.
- ❑ Avoid personnel exposure and/or area contamination by shielding waste containers as required, minimizing the quantity of waste stored in labs, and using double containment of liquids.
- ❑ Do NOT place radioactive waste in an ordinary trash receptacle.

- Whenever possible, reduce the volume of radioactive waste you generate. Monitor waste items for contamination. If uncontaminated, deface all radiation labels and markings and dispose of properly—but not as radioactive waste. Examples of uncontaminated materials that can be disposed of as ordinary waste include packing materials, clean paper, and similar materials.
- If you find an item labeled with a “radioactive material” label or tape but the material is not contaminated, remove or completely deface the label(s). Dispose of these non-radioactive materials as described immediately above.
- Do not mix hazardous waste with radioactive waste (e.g., no lead “pigs” in radioactive waste).
- If a hazard can be eliminated legally at the point of generation, do so; for example, some biohazards can be eliminated by sterilization. Contact EH&S for assistance (642-3073).
- Use only waste containers provided or approved by EH&S. These containers must also be chemically compatible with the material being placed into them.

Waste labeling

All waste containers must be properly labeled. At minimum, the labeling must include:

- RH’s name.
- Date the waste was first placed into the container.
- Name and activity of each isotope in the container.
- Other hazardous materials in the container (e.g., flammable, corrosive, toxic, reactive).

Other, specific labeling requirements are described by type of waste below.

Solid radioactive waste

- Place all solid radioactive waste in plastic-lined containers approved by EH&S.
- To protect personnel from injury, place all sharp items (hypodermic needles, glass, pipettes) in a puncture-proof sharps container.
- Do not mix solid waste with liquids, animal remains, or active pathological agents.

Liquid radioactive waste

- Collect radioactive liquid wastes in EH&S-approved containers.
- Maintain liquid wastes at a pH between 5 and 10.
- Keep liquids containing iodine slightly basic (pH 8–10), to reduce iodine volatilization.
- Place aqueous and water-soluble materials into separate containers from non-aqueous and water-insoluble materials.
- Put all liquid-waste containers into secondary containers (e.g., plastic dish pans or paint cans) big enough to contain all the bottled liquid in case of breakage or leaks.
- Do not mix solid materials, animal remains, or active pathological agents with liquid waste.

Animal waste

- ❑ Place all radioactively contaminated animal carcasses, tissues, and excreta into sealed double plastic bags.
- ❑ Place carcasses containing 0.05 $\mu\text{Ci}/\text{gram}$ or less of ^{14}C or ^3H in separate bags from all others.
- ❑ Label all remains properly.
- ❑ Freeze all animal waste in your laboratory or in a specially designated and labeled department freezer.

Liquid scintillation cocktail (LSC) vials

- ❑ Place bags of LSC vials into containers approved by EH&S.
- ❑ Keep separate from all other wastes.

Other wastes

In cases where radioactive material will not be disposable as outlined above, consult EH&S before the waste is generated. Special procedures may be required by the RSO and/or the RSC.

F-14 Sealed Sources

- ❑ A physical inventory of licensed sealed sources is required to be completed and documented once every six months. The RST will provide information to the RHs for sealed sources on how this is to be documented.
- ❑ Most sealed sources must be leak tested every six months for leakage. 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.

APPENDIX G

Use of Radiation in Animals and Humans

This appendix provides additional information to Section 3.2.3, “Application for Use of Radiation in Animals.” And the Section 3.2.4, “Application for the Use of radiation in Humans.”

G-1 Use of Radiation in Animals

Research involving 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, requires both an RUA and approval by the ACUC. The EH&S RST will start the authorization process, but does not complete the RUA or obtain required approvals until the ACUC has approved the animal-use protocol.

On receiving ACUC approval, the EH&S RST reviews the final protocol, makes any required RUA modifications, and obtains the required approvals. Information related to the animal use protocol is included on the RUA. No work with animals that exposes them to radiation or radioactive materials may be performed without both ACUC approval and an RUA. Additional information on animal uses can be found on the ACUC website, <http://www.acuc.berkeley.edu/>.

G-2 Use of Radiation in Human **Subject** Research

All research on humans requires approval from the Committee for the Protection of Human Subjects (CPHS). If human subjects will be exposed to radiation from radiation producing machines then both a Radiation Use Authorization (RUA) and approval by the CPHS are required. The EH&S Radiation Safety Team (RST) will start the authorization process, but will not issue the RUA until the CPHS has approved the human subject research protocol.

CAUTION: 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.

The EH&S RST reviews the protocol and obtains the required approvals from the RSC. Information related to the human use protocol is included on the RUA. Administration of radiation from a radiation producing machine to human research subjects must not be performed without both, an up-to-date CPHS approval and a current RUA.

The California Department of Public Health (CDPH) does not currently have regulations unique to use of radiation producing machines for human research, not associated with diagnostic or therapeutic purposes. At this time, human subject research could be conducted using a radiation producing machine, provided the machine is operated by a person issued a “permit” or “certificate” under the

supervision of a “licentiate” as defined by CDPH.

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CAUTION: 17 CA ADC § 30305 (b) (4) states, “Deliberate exposure of an individual to the useful beam for training or demonstration purposes shall not be permitted unless there is also a medical or dental indication for the exposure and the exposure is prescribed by a physician or dentist.”

The US Food and Drug Administration (FDA) sets radiation dose limits for research involving radioactive drugs in 21 CFR Part 361.1. In the absence of other Federal regulations or CDPH requirements, the UC Berkeley Radiation Safety Officer (RSO) and Radiation Safety Committee (RSC) will use the following FDA criteria in approving human use research involving exposure to ionizing radiation from radiation producing machines if:

- The radiation dose is justified by the quality of the study being undertaken and the information it seeks to obtain,
- The amount of exposure administered shall be such that the subject receives the smallest radiation dose with which it is practical to perform the study without jeopardizing the benefits to be obtained from the study,
- Under no circumstances may the radiation dose to an adult research subject from a single study or collectively from a number of studies conducted within one year be generally recognized as safe if such dose exceeds the following:

Whole body, active blood-forming organs, lens of the eye, and gonads	Rem
Single dose	3
Annual and total dose commitment	5
Other organs	
Single dose	5
Annual and total dose commitment	15

- For a research subject under 18 years of age, the radiation dose shall not exceed 10 percent of that set forth above,
- Radiation doses from radioactive material administered by another licensee that are part of the research study (i.e., would not have occurred but for the study) shall also be included. The possibility of follow-up studies shall be considered for inclusion in the dose calculations, and
- Numerical definitions of dose shall be based on an absorbed fraction method of radiation absorbed dose calculations, such as the system set forth by the Medical Internal Radiation Dose Committee of the Society of Nuclear Medicine, or the International Commission on Radiological Protection; and consistent with 10 CFR Part 20 as accepted by the CDPH.

Given the special requirements for human use research, the RSO and RSC may not be appropriately qualified to evaluate the proposed protocol. In that case, the RSC Chair may convene a Radiation

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Human Use Committee of at least five individuals in accordance with its bylaws. The committee

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will include the following three individuals: (i) A physician recognized as a specialist in radiology or nuclear medicine, (ii) a person qualified by training and experience in medical physics, and (iii) a person with special competence in radiation safety and radiation dosimetry with prior experience evaluating human use protocols involving radiation exposure. The remainder of the committee should consist of individuals qualified in various disciplines pertinent to the field of radiology or nuclear medicine (e.g., internal medicine, clinical pathology, hematology, endocrinology, radiation therapy, radiation physics, radiation biophysics, health physics and radiopharmacy). The membership must be sufficiently diverse to permit expert review of the technical and scientific aspects of proposals submitted to the committee. The RSC Chair may elect to recruit the services of another campus' established Radiation Human Use Committee for this purpose provided that committee meets the above criteria and the UC Berkeley RSC reviews the committee's report and votes to approve their conclusion.

Additional information related to the conduct of research involving human subjects can be found at the CPHS website, <http://cphs.berkeley.edu>.

Note: Medical and dental exposure for detection or treatment, performed in accordance with applicable state regulation, are exempt from this section.

APPENDIX H

Radiation-Producing Machines (RPMs)

This appendix provides additional information to Section 3.6 of the *Radiation Safety Manual*.

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

- electron microscopes
- medical machines
- cabinet X-ray machines
- X-ray diffraction and fluorescence analysis machines
- miscellaneous machines including accelerators

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General Regulations

H-1 Possession

- Notify the Radiation Safety Officer (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 and obtain a valid Radiation Use Authorization (RUA) before acquiring or operating a machine, regardless of means of acquisition (purchase, lease, gift, loan, “in-house” fabrication) and regardless of ownership.
- All individuals, except electron microscope users, must complete the online RPM Safety Training to be listed on an RUA. However, the RH and laboratory contact for an electron microscope must complete the RPM Safety Training since they are responsible for maintenance of the unit.
- 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:

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“DEACTIVATED RADIATION-PRODUCING MACHINE. DO NOT MOVE, DO NOT OPERATE, DO NOT REACTIVATE WITHOUT NOTIFYING EH&S RADIATION SAFETY. CALL 642-3073”

- ❑ Provide sufficient lead time (at least one week) before acquiring or disposing of machines.
- ❑ The RSO renews the registration of all campus RPMs with the CDPH as required.

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H-2 Use

- ❑ Operate RPMs in accordance with a valid RUA. Among other items, the RUA lists the AU 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 RUA (usually for test and/or alignment purposes). Record authorized bypass operations in the “Use Log”.

H-3 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 repairperson 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.

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H-4 Radiation Exposures

RPMs must be used in accordance with the manufacturers’ instructions so that (1) the radiation exposure to operators and others in the vicinity is **As Low As Reasonably Achievable (ALARA)**, and (2) use of the machine does not exceed the exposure limits specified in Title 10CFR20 and Title 17, CCR.

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H-5 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.

H-6 Machine 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).

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H-7 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 areas must be posted as required.
- ❑ A copy of the UC Berkeley “Radiation-Producing Machine Safety Procedures” must be posted in the immediate vicinity of each machine.
- ❑ A copy of the UC Berkeley “Radiation-Producing Machine Standard Operating Procedures” must be available in the immediate vicinity of the machine that it was written for.

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H-8 Radiation Surveys

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

- ❑ Before routine use starts
- ❑ Following any major changes in configuration or repair
- ❑ At least once a year

Periodic surveys for radiation leakage and tests of interlock and power/shutter status indicators are required for many RPMs. Where required, RHs must maintain permanent written records of such surveys and tests. Details of such requirements will be indicated on the RUA form that applies to the RPM.

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H-9 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 annual or more-frequent inspections to ensure the machines' ongoing safety and compliance including verification of interlocks, when required. | 3

H-10 Dosimetry

In general, individuals working in areas where the potential for exposure to radiation meets the criteria specified in section 4.5 of the RSM must wear dosimetry as specified on the RUA for that machine. In most situations, the RSO will not specify use of dosimeters 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 dosimeters are issued by EH&S, and must be worn as specified by the RUA. | 3

H-11 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 guidelines apply to all RPMs:

- ❑ Safety devices must be in working order before the machine is operated.
- ❑ Only authorized repairpersons 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. These devices exist as backup only, and do not replace proper training, procedures, and practices. 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. | 3
- ❑ 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, | 3

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.

H-12 Standard Laboratory Operating Procedures (SOP)

EH&S provides RHs with SOP templates. The RH must provide a copy of the operating procedures to the EH&S RST and to every user, and keep a copy available in the work area. |
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Each user of an RPM must read the unit-specific SOP and document that he/she has read the SOP in the RH's system of records prior to use of the RPM. |
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H-13 "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 |
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- ❑ Description of use
- ❑ Beam voltage
- ❑ Beam current
- ❑ Time beam turned on
- ❑ Time beam turned off
- ❑ Operational abnormalities, repairs, etc.

H-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.

H-15 Electron microscopes

- ❑ Valid and current RUA with operator name

- ❑ Training
- ❑ Operating log
- ❑ Dosimetry, as assigned
- ❑ Adherence to RUA requirements
- ❑ Notification to EH&S of any changes to use, machine, personnel, or protocol.

H-16 Diagnostic Medical machines

- ❑ Valid and current RUA with operator name
- ❑ Posting of CDPH certificates
- ❑ 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) Reports numbers 33, 35, and 49 and their successors. EH&S provides oversight of these operations, installation designs, etc. to make sure this requirement is met.

H-17 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 0.2 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.

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H-18 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 0.2 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 0.2mrem 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.

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H-19 Field Radiography

- Special controls are required for field radiography as stated in 17 CCR§30336.1.
- The RSO will only approve RUAs for field radiography after verifying compliance with the applicable portions of 17 CCR§30336.1.

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H-20 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 are similar to those required for the other four machine categories.

APPENDIX I

Special Information for Pregnant Workers

This appendix provides information which is supplementary to that found in Section 4.4, “Prenatal Radiation Exposure Policy” of the *Radiation Safety Manual*.

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Federal and state regulatory agencies have established the category of “declared pregnant worker” in order to address radiation exposure to the fetus.

UC Berkeley’s administrative criteria for external and internal dosimetry for declared pregnant workers are often lower than those established for other individuals who use radiation (e.g., penetrating gamma radiation emitters and most internal exposures).

Each worker elects whether to declare (in writing) that she is pregnant (see Section 4.4, “Prenatal Radiation Exposure Policy,” of the *Radiation Safety Manual* for additional details and a link to a form that may be used). If a campus radiation user declares her pregnancy in writing, she must be treated as a “declared pregnant worker”. She may choose to limit her exposures to the regulatory dose limits for a declared pregnant worker and her developing embryo/fetus. She may also be asked to modify her work and/or to use special dosimetry for the duration of her pregnancy.

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I-1 Specific Information for Prospective Mothers

“Prospective mothers” are workers who are pregnant or actively trying to become pregnant, whether or not they become “declared pregnant workers.” It is UC Berkeley’s policy to inform female radiation workers (employees and students) of the following:

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- ❑ The risks to the developing embryo/fetus from exposures to ionizing radiation.
- ❑ The options available to maintain such external and internal exposures as low as reasonably achievable (ALARA) below the *in utero* legal limit of 500 mrem for “declared pregnant workers.”

All female radiation workers are strongly encouraged to contact the RSO if they have questions regarding radiation exposures during pregnancy. These calls, and the medical status of all individuals, are kept strictly confidential.

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I-2 Special Precautions for Prospective Mothers

UC Berkeley recommends certain precautions for prospective mothers (whether or not they are “declared pregnant workers”) who choose to continue working with or around radioactive materials and/or radiation-producing equipment:

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- ❑ The prospective mother who uses or works around radiation sources is encouraged to consult with the RSO regarding any radiation safety questions and concerns.
- ❑ The prospective mother should avoid situations in which her abdomen may be exposed to penetrating radiation (gamma, X-ray, neutron) levels greater than two (2) mrem per hour or 10 mrem per week.
- ❑ Before adopting any special measures intended to reduce radiation exposure (e.g. use of a protective apron), the prospective mother should consult the RSO. The RSO will be able to determine if the planned actions will actually reduce the radiation exposure. For example, the effectiveness of protective

aprons in reducing radiation exposure depends on the type of radiation that will be present. Thin lead aprons may be effective for X rays, but they are not generally not appropriate for use around gamma emitters (such as Cr-51) or beta emitters (such as C-14 or P-32). The RSO can advise the prospective mother on the best combination of time, distance, shielding (including protective aprons), and controls to minimize the dose to her and her fetus/embryo.

- The RSO may ask a prospective mother to wear a radiation dosimeter as a “fetal dose monitor.” This monitor assesses penetrating radiation exposures from external sources (gamma, X-ray, neutron) to the prospective mother’s abdomen. The RSO reviews the dosimetry results, provides the prospective mother with information as to the dose, if any, and communicates any suggested work changes.
- The prospective mother should contact EH&S about working with volatile or reactive radiochemicals that could result in the inhalation, ingestion, or absorption of radioactive materials through her skin.
- In any case of suspected accidental exposure to radiation sources or uptake of radioactive materials, the prospective mother should immediately contact the campus RSO or the EH&S RST (642-3073). Campus police (UCPD) can contact EH&S during off hours.

APPENDIX J

Glossary of Terms

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) 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 ⁴⁰K (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).

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 woman 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.
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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. 3

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]

NSTS. National Source Tracking System

NMMSS. Nuclear Material Management and Safeguard System

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.

prospactive mothers. Women who use or work near ionizing radiation sources and who are pregnant or actively trying to become pregnant, whether or not they become “declared pregnant workers”.

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**.)

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. 3

special nuclear material. (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). See Appendix F. 2

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.

See appendix K for Acronym Guide.

APPENDIX K

Acronym Guide

The following acronyms are used throughout this manual and its appendices:

ACUC	ANIMAL CARE AND USE COMMITTEE	
ALARA	AS LOW AS REASONABLY ACHIEVABLE	
CAC	<u>CALIFORNIA ADMINISTRATIVE CODE</u>	
CCR	<u>CALIFORNIA CODE OF REGULATIONS</u>	
CFR	<u>CODE OF FEDERAL REGULATIONS</u>	
CPHS	<u>COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS</u>	
CDPH	CALIFORNIA DEPARTMENT OF PUBLIC HEALTH	
EH&S	ENVIRONMENT, HEALTH & SAFETY (OFFICE OF)	
NRC	NUCLEAR REGULATORY COMMISSION	
RPM	RADIATION-PRODUCING MACHINE	
RSC	RADIATION SAFETY COMMITTEE	
<i>RSM</i>	<i>RADIATION SAFETY MANUAL</i>	
RSO	RADIATION SAFETY OFFICER	
RST	RADIATION SAFETY TEAM	3
RUA	RADIATION USE AUTHORIZATION	
SNM	SPECIAL NUCLEAR MATERIAL	3
SOP	STANDARD OPERATING PROCEDURE	
UC	UNIVERSITY OF CALIFORNIA	
VCR	VICE CHANCELLOR FOR RESEARCH	

SEE APPENDIX J FOR GLOSSARY OF TERMS.

APPENDIX 1

Statutes and Regulations

The following statutes and regulations and amendments thereto may apply to UC Berkeley. These regulations are expressly incorporated into the *Radiation Safety Manual*, radiation safety procedures, and campus radiation safety program.

1-1 Federal Statutes and Regulations

- ❑ U.S. Atomic Energy Act of 1954.
- ❑ U.S. Radiation Control for Health and Safety Act of 1968.
- ❑ U.S. Atomic Energy Commission Regulations, Title 10, applicable sections of Code of Federal Regulations, Chapter I (now nuclear Regulatory Commission of NRC).
- ❑ U.S. Food and Drug Administration, Department of Health, Education and Welfare Regulations, Title 21, Code of Federal Regulations, Chapter I, Subchapter J.
- ❑ U.S. Department of Transportation Regulations, Title 49, Code of Federal Regulations, Chapter I, Parts 170–199.
- ❑ U.S. Environmental Protection Agency Regulations, Title 40, Code of Federal Regulations, Chapter I.
- ❑ Regulations of Other Miscellaneous U.S. Government Agencies, Code of Federal Regulations, Titles 10, 14, 39 and 46.

1-2 California Statutes and Regulations

- ❑ California Health and Safety Code, Division 104, Part 9, Radiation.
- ❑ California Radiation Control Regulations, Title 17, California Code of Regulations, Chapter 5, Subchapter 4.
- ❑ California Radiologic Technology Regulations, Title 17, California Code of Regulations, Chapter 5, Subchapter 4.5.
- ❑ General Industry Safety Orders, Title 8, California Code of Regulations.

Many of these codes and regulations are available for reference at EH&S and at UC Berkeley libraries.

APPENDIX 2

Responsibilities of the Radiation Safety Committee (RSC)

This Appendix provides supplemental information to Section 2.3 of the *Radiation Safety Manual*.

The UC Berkeley Radiation Safety Committee (RSC) works with executive management and the Radiation Safety Officer (RSO) in overseeing the radiation safety program, and in establishing campus policies and procedures related to radiation safety.

The committee is appointed by the Chancellor (or the Chancellor's designee) and advises the Chancellor, Vice Chancellor for Research (VCR), the Office of Environment, Health & Safety (EH&S), and others on radiation safety issues. The RSC meets as often as required (but no less than once each calendar quarter) to review radiation program activities and other matters related to the committee's charge.

The RSC must act in the best interests of radiation safety and has the authority to terminate a Radiation Use Authorization (RUA), if warranted. RSC responsibilities include:

- ❑ Review personnel dosimetry data, discussing the results of required radiation surveys, and any significant incidents, including spills, contamination, etc.
- ❑ The RSC reviews any consultant's audit findings and acts upon those findings.
- ❑ The RSC reviews possible trends and makes suggestions for timely and corrective action.
- ❑ Review processes that are intended to ensure that all uses of radioactive materials and/or RPMs are conducted safely, doses are ALARA and in accordance with all laws, regulations, and conditions of the license.
- ❑ Establish policies to ensure that all individuals who work with or near radioactive materials or RPMs have sufficient training and experience to perform their duties safely and in accordance with laws, regulations, and conditions of the license.
- ❑ Ensure that every RUA is reviewed at least once every three years and renewed as appropriate. If deemed necessary, the RSC (or RSO) may require a more frequent review schedule or authorize the RUA for shorter periods.
- ❑ At its discretion, review RUA Holder (RH) — noncompliance matters referred by the RSO and determine appropriate actions, which may include modifying, restricting, or terminating the RUA. Refer to Appendix 5 for details on the RUA review and approval process.
- ❑ Provide technical direction and information on campus radiation-safety policy. Perform an annual review of EH&S radiation safety and waste operations and procedures. The review includes an examination of pertinent records, reports from the RSO, results of state inspections, written safety procedures, annual Radiation Safety Audit Report, and management-control systems. (EH&S provides whatever reports, summaries, and statistics the RSC may require for its review.) The RSC recommends remedial action to correct deficiencies identified in the radiation safety program.
- ❑ Review issues brought to its attention that may affect campus radiation safety, changes in radiation safety policy, and changes in standards or regulations related to radiation safety.
- ❑ Approve or require changes in procedures and programs. The Radiologic Health Branch (RHB) of the CDPH has granted "Broad-Scope A" licensees the additional flexibility described in NUREG 1556 V11

to make programmatic changes and to revise procedures without RHB approval. That is, the RSC may approve a change in procedures or programs by reviewing and documenting the specific change, stating the reason for the change, and summarizing the radiation-safety matters that were considered prior to approval. A copy of the review becomes part of the RSC minutes.

- ❑ In the case of an approved programmatic change, determine whether an amendment to the Radioactive Materials License is required, and review and approve that amendment. A copy of the determination becomes part of the RSC minutes.
- ❑ Review individual incidents to determine that all activities are conducted safely and in accordance with state regulations and the conditions of the license.
- ❑ Serve as a source of information on radiological safety. Ensure that pertinent information is provided to all users or other individuals. Recommend user-training guidance, courses, and other means of improving personnel's level of expertise.
- ❑ If necessary, and with the addition (as-needed) of qualified individual(s), act as the Radiation Human Use Committee.

4

A copy of the Bylaws of the RSC are available at the EH&S website or by request.

APPENDIX 3

Exempt Quantities

The list of Exempt Quantities provided by the DHS in Title 17 CCR § 30180 is incorporated by reference.

| 3

APPENDIX 4

Record Keeping: Office of Environment, Health & Safety (EH&S)

This Appendix provides additional information to Section 6, "Record Keeping", of the *Radiation Safety Manual*.

The Radiation Safety Officer (RSO) is responsible for meeting all record-keeping requirements. These records include the registration of sources of hazardous radiation, Radiation Use Authorizations (RUAs), inventory of radioactive materials, disposal records for radioactive waste, monitoring records, inspection reports, and other records required by the State of California, the Nuclear Regulatory Commission (NRC), and other enforcing agencies.

In particular, the RSO is responsible for ensuring the following records are maintained:

- ❑ RUA applications and authorizations.
- ❑ RUA revisions, amendments, or renewals.
- ❑ Personnel records, including training and experience forms, copies of all training documents, and declarations of pregnancy.
- ❑ EH&S Radiation Safety Program audits conducted in compliance with this manual. (Audit records are kept for at least three years.) | 3
- ❑ Dosimetry records.
- ❑ Bioassay records.
- ❑ Sealed-source leak test results.
- ❑ Records of any major spills and/or gross contamination of facilities.
- ❑ Source, special nuclear material, and nationally tracked sources, inventory, and transfer records. | 2
- ❑ Records necessary to comply with radiological decommissioning requirements | 3

At the time a RUA is terminated, the RSO acquires records formerly kept by the RUA Holder (RH). These include:

- ❑ A copy of the approved RUA.
- ❑ Documentation of on-the-job training provided to laboratory personnel.
- ❑ Copies of the Radioactive Material Inventory audits and verifications. | 3
- ❑ Disposal records for isotopes and contaminated laboratory material, indicating the date, activity, physical or chemical form, and method of disposal.
- ❑ Laboratory self-surveys.
- ❑ A complete history of and corrective action taken for, any major spill and/or gross contamination of facilities.
- ❑ Data demonstrating compliance with any special requirements of the RUA.
- ❑ Records of transfers of radioactive materials.

APPENDIX 5

Radiation Use Authorization (RUA) Process

Request Overview

Requests for use of radioactive materials and/or radiation-producing machines (RPMs) under the campus license are initiated by the prospective RUA Holder through a request to the Radiation Safety Officer (RSO). In response to this request, the prospective user is provided an application form and a copy of the *Radiation Safety Manual* (both also available on the EH&S website <http://ehs.berkeley.edu/>). These requests are processed as follows.

5-1 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). Where applicable, the following specific factors are evaluated and recorded in a project analysis:

- Training and experience of the applicant and assistants.
- The radioisotope, its activity, and its chemical and physical form.
- Experimental protocol and specific methods for conducting the phase of the experiment involving radioactive materials or ionizing radiation.
- Adequacy of all workplaces for the proposed radiation use with respect to:
 - Storage facilities
 - Hoods, glove boxes, other special equipment
 - Housing and care of experimental animals (if used)
 - Effect of radiation use on surrounding areas
 - Housekeeping levels in proposed areas
 - Room diagrams labeled with locations where radiation is to be used
- Radioactive materials and ionizing radiation control:
 - Inventory records
 - Use records
 - Waste disposal
 - Storage and labeling
- Environmental control:
 - Monitoring methods, frequency, and records
 - Radiation-detection equipment
 - Area posting and access control
 - Contamination-control procedures
 - Radiation-levels and shielding requirements
 - Levels of volatile or dispersible radioactivity

- Protection of personnel:
 - Dosimetry requirements
 - Bioassay requirements
 - Protective-clothing requirements
- If applicable, a description of the RPM, the maximum tube voltage, and the maximum tube current.
- ALARA:

Appropriate quantities and procedures to keep occupational and public radiation doses as low as reasonably achievable (ALARA).
- Classification:

A Hazard Guide Value (HGV), in order to establish the classification of the use as Class I, II, or III (low, medium, or high radiological hazard).
- Radioactive waste:

As part of the review, the RSO discusses campus radioactive waste-minimization methods and makes suggestions for waste reduction under the RUA. The user is provided information on the segregation, labeling, packaging, and pickup of radioactive wastes. (See also section K of the Radiation Safety Logbook.)

5-2 Preparation of the RUA

Following the review above, the Radiation Safety Team (RST) prepares a project analysis and pending RUA using the Radiation Safety Information System (RSIS), defining the scope of the proposed radiation use. This pending RUA includes classification, location, a listing of personnel, description of radiation use, limits of use, required work precautions, and personnel protective devices and dosimetry.

3

The RSIS will sum the type, form, and quantity of radioactive material being requested with all other RUAs and compare the total amount against the amount of radioactive materials authorized by the UC Berkeley Radioactive Material License and other regulatory requirements. An RUA cannot be issued if the license limits or regulatory requirements might be exceeded.

3

5-3 RUA Holder (RHs) Review

The RST sends the project analysis and pending RUA to the RH, who signifies agreement and approval by signing the RUA and obtaining the signature of the Department Chair. The signed RUA is returned to the RSO.

3

5-4 Final Review and Approval

After receiving the signed RUA, the RSO obtains the appropriate RSC approval, making it final. Questions or disagreements concerning review and approval of an individual RUA are resolved by the RSC. What follows is an outline of the review and approval process for each classification of RUA.

Initial applications to use radioactive materials and ionizing radiation:

Class I (low radiological hazard)

Initial Class I draft RUAs are reviewed by the RSO. If no further review is needed by the RSC, the RSO approves the RUA and distributes copies. If further review is needed, the RSO submits the pending RUA to the RSC Chair for review and approval. If the RSO discusses a Class I RUA with the RSC Chair, the Chair may approve the RUA or ask that the RUA be reviewed by the RSC. Work cannot start until the RUA approval process has been completed and an approved RUA has been issued.

3

Class II (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 interim approval. The RUA goes into effect, but is re-reviewed by the RSC at the next committee meeting. If the RSC challenges approval, the RSO is given specific instructions as to how to proceed. Work cannot start until the RUA interim approval process has been completed and an approved RUA has been issued.

3

Class III (high radiological hazard)

Following the RSO’s review, the pending RUA is submitted to the RSC Chair for provisional approval. The provisionally approved RUA is then submitted to the full RSC for consideration at its next meeting. 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 provisional RUA approval process has been completed and an approved RUA has been issued.

3

A signed copy of the RUAs is sent to the RH and the original is filed in the RUA folder.

3

5-5 Renewal of RUAs

RUAs are valid for a maximum of three years. 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.

3

If during the course of the renewal survey, or as a result of other sources of information, it
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becomes clear that the RH has not used radioactive material for one year; the surveyor should determine if the RH plans on using radiation or radioactive material in the next year. If no use is planned and the inventory is locked up and/or the RPM is locked out such that it can not produce radiation, then the RUA may be put on "hold." Being on hold status means that the RUA self-survey requirements may be suspended. If the RH decides after one year of non-use that there is no plan to use radioactive material or RPM in the next year; the RUA can continue in a "hold" status, but the RH must dispose of the radioactive material or RPM and perform the surveys and other actions necessary to terminate the RUA before the end of the second year.

During the period the RUA is on hold the RST will usually not perform routine surveys. However, radiation safety may always perform a survey if there is reason to believe that a survey is warranted. For all RUAs on hold, radiation safety must perform the 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 Radiation Safety Officer prior to actual work with radioactive materials or radiation producing machines is begun. This notification requirement will be added to the RUA list of precautions and requirements for any RUA that is placed on hold.

The RH must request specific RSC approval to renew any RUA that has been on "hold" for two consecutive years. The RSC will not approve any request to keep a RUA on hold for more than a total of three consecutive years.

This control is established to prevent RUA's from being abandoned in place rather than completing the termination process.

5-6 Notification of Approval

The RSO files the approved RUA and distributes copies to the RH. Subsequent revisions of the RUA need not be signed however if the changes rises to the level of an amendment, the pending RUA amendment will be routed for signature.

5-7 Additional Information

The following subsections describe how determinations are made regarding classification of radioactive material RUAs according to use, as well as the survey frequencies, the need for dosimetry, the need for survey meter(s), and additional RUA precautions.

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 HGV may be modified by the RSO at any time.

Method of HGV computation

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: 3

$$\text{Individual HGV} = Q_i T_i U_i W_i$$

Where:

Q_i = Quantity of a radionuclide in microcuries

T_i = Relative Toxicity Factor 3

U_i = Use Factor

W_i = weighting factor for experiment, order, or possession

Total HGV = sum of the highest individual HGVs for each listed radionuclide 2

Factors used in HGV formula

- a. Quantity of the radionuclide is expressed in microcuries.
- b. 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 H3, C14, and I125. 3

Table 7: Relative Toxicity Factor

Relative Toxicity Factor	Examples	Relative Radiotoxicity
100	(²³⁹ Pu, ²³³ U, ²³⁵ U)	Very high
10	(¹²⁵ I, ²² Na)	High
1	(³² P, ¹⁴ C, ³⁵ S)	Moderate
0.1	(³ H)	Low

Table 8: Additional T_i Values for Isotopes According to Relative Radiotoxicity Per Unit of Activity¹

Taken from NUREG 1556/V11, Appendix 2, Table S.4

Relative Toxicity Factor	Isotopes
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-191 Pt-193 Pt-197 Au-196 Au-198 Au-199 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-91m 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

1

- c. Use Factor (U_i) is based on the proposed use of the radioisotope. Consideration is given to the
- d. probability of 1) release of the radioisotope to the environment, 2) contamination of persons engaged
- e. in the operation, and 3) contamination of equipment and facilities. Here are some examples:

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Table 9: Use Factors

Type of Operation	Typical Use Factor (U)
Sealed sources	0.001
Storage of unsealed radioisotopes	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

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

Table 10: Weighting Factors

Phase	Factor
Experimentation	1
Order handling	.1
Storage	.01

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2

Determination of RUA Classification

The HGV is used to determine the RUA classification as follows:

HAZARD	HGV	RUA Class
Low	0–500	Class I
Medium	> 500–50,000	Class II
High	> 50,000	Class III

Discussion of Workplace Classification and Typical Requirements

Class I

Most low-level work with unsealed radioactive material can be safely conducted in an ordinary laboratory equipped and operated as follows:

- Work surfaces for radioactive experiments must be smooth and impermeable.
- Radioactive materials must be stored in suitable refrigerators and freezers.
- Gloves, eye protection, and lab coats must be worn.
- Absorbent paper must be used on work surfaces.
- Properly labeled waste-disposal containers must be available.
- Spill cleanup materials must be provided.
- The area must be securable.

Class II

This classification applies to medium and moderately high-level radioisotope work. In addition to meeting design criteria described above for Class I, Class II workplaces may also require the following:

- Local shielding.
- Remote handling equipment.
- More sophisticated storage facilities.
- Fume hoods with an average air flow across the face of 100 linear feet per minute (LFM).
- Special enclosures.
- Access control.
- Portable survey and monitoring equipment.

Class III

This classification applies to high-level radioisotope work. In addition to meeting design criteria described above for Classes I and II, Class III workplaces may also require the following:

- High-efficiency filtration of exhaust ventilation.
- Glove boxes with appropriate filters.
- Remote manipulators.
- Isolation from other work areas.
- Clothing change area.
- Radiation monitors with alarms.
- Continuous air monitors with alarms.
- Sophisticated wash and storage facilities.

Determination of RUA Dosimetry Requirements

The RSO reviews the RUA uses, isotopes, and amounts. Dosimetry requirements are established using the guidance in Appendix 7, “External Dosimetry,” and are indicated on the RUA. The requirement(s) are modified by the RSO based on experience or use changes.

3

Determination of Survey Instruments for RUAs

The RSO reviews the RUA uses, isotopes, and amounts. Survey meter requirements are established, using the guidance below, and are indicated on the RUA. The requirement(s) are modified by the RSO based on experience or use changes.

In general, appropriate:

- ❑ Contamination survey meters are required for the use of unsealed radioactive material in excess of 10 times the exempt quantities presented in 17 CCR §30235. Schedule A and § 30237 Schedule C,
- ❑ Dose rate survey instruments are required for any source that can produce an exposure rate in excess of 2 mr/hr at 30 cm from the source, and
- ❑ Dose rate survey instruments are required for any RPM that can produce more than 0.5 mr/hr at five centimeters from the accessible portion of the external surface of the device during operation and for entry into any area where the beam may be present such as during alignment or following activation of an interlock.

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Note: A low-energy gamma scintillation detector may be required for use of Iodine 125.

The RSO makes the final determination as to what survey meters are required by laboratories. 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.

3

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

The RSO reviews the RUA uses, isotopes, and amounts. Using the guidance 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. This survey frequency is determined by the RSO based on the radiological hazard (Class for material) and compliance with conditions of use.

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These surveys are categorized as:

- ❑ Routine (typically quarterly for Class III, semi-annually for Class II and annually for Class I use of unsealed radioactive material), annually for Class I sealed sources and semiannually for RPMs unless a unique or significant radiological hazard exists)
- ❑ Renewal (typically not less than once every three years)

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- ❑ More frequently surveys are conducted for new users and based on poor performance for experienced users
- ❑ Termination

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Details of the Radiation Safety Surveys (audits)

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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 guidelines.

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 protocol, provides information for training of laboratory staff, and reviews the compliance history for the RUA for the past year(s).

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Special surveys are performed as needed to address issues in the laboratory. An example would be a spill, or work on the trap for a sink used to dispose of liquid radioactive waste.

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.

2

Frequency of EH&S Radiation Safety Surveys

Audit (EH&S survey) frequency is based on potential hazard as determined by the RSO. The frequency of these EH&S surveys is independent of the frequency of user self-surveys. At the initiation of an RUA, the RSO reviews factors that include:

- a. A detailed review of the proposed project
- b. An inspection of the proposed workplace(s)
- c. Training and experience of the applicant and assistants
- d. The radioisotopes, their activities, and their chemical and physical forms
- e. Procedures to be followed in using the requested radioactive materials
- f. Experimental protocol and specific methods for conducting the phase of the experiment involving radioactive materials or ionizing radiation

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- g. Adequacy of rooms, laboratories, and other workplaces for the proposed radiation use with respect to:

- Storage facilities
- Hoods, glove boxes, and other special equipment
- Housing and maintenance of experimental animals (if used)
- Effect of radiation use on surrounding areas
- Housekeeping levels in proposed areas
- Specific locations where radiation is to be used
- Inventory records
- Use records
- Waste disposal
- Storage and labeling
- Environmental controls
- Monitoring methods, frequency, and records
- Radiation-detection equipment.
- Area posting and access control
- Contamination control procedures
- Possible radiation levels and shielding requirements
- Possible levels of volatile or dispersible radioactivity
- Sinks
- Protection of personnel
- Dosimetry requirements
- Bioassay requirements
- Protective-clothing requirements
- Keeping doses ALARA

The RSO or designee's review of these items 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.

Determination of Frequency of RUA Holder (RH) Self-Surveys

Appendix F-11 should be used to identify the frequency of self-surveys to be performed by the RUA authorized users. These surveys are specified on the individual RUA. Information on how these surveys are to be performed is provided in training given by EH&S and in the Radiation Safety Logbook.

- All incoming shipments of radioactive material to the laboratory must be surveyed within three hours of receipt on routine work days.
- A survey must be conducted of the immediate work area after all iodinations, and if more than one mCi of any other isotope is used. If H-3 is used exclusively, only swipes are required.
- 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-surveys.
- The minimum user self-survey frequency is indicated on the RUA. Appendix F, Tables 2 and 3 indicate general guidelines. Required survey frequencies may be modified at the discretion of the RSO or RSC.

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.

5-8 Termination of RUAs

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

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 present an undue of 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 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.

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

5-9 Action taken on RUA termination

Upon termination of an RUA, all radioisotopes 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. | 3

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

5-10 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 isotopes 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.

5-11 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 isotope(s), isotope-limit changes that change the Hazard Guide Value and RUA Class, use of a new protocol, the addition of the use of animals, etc.

Class I

Class I RUA **amendments** are reviewed and approved by the RSO. As requested by the RSC Chair, copies of the RUA and attachments are distributed to the RSC and discussed at the next RSC meeting.

Minor changes (such as room changes) are handled by EH&S as RUA **revisions**, and do not require RSO or RSC review or approval.

Class II

Class II RUA **amendments** are approved on an interim basis by the RSO. Normally, the RSO reviews and summarizes the information and presents it at the next RSC meeting. In some cases, the summary and proposed change are provided to each RSC member for review before the meeting. Amendments with no significant changes to the initial authorization are normally approved by the RSO. Copies of the RUA and attachments may be distributed to the RSC and discussed at the next committee meeting.

Minor changes (such as room changes) are handled by EH&S as RUA **revisions**, and are approved by the RSO.

Class III

Class III RUA **amendments** are approved by the RH, RH Chair, RSO and provisionally by the RSC Chair. The RSO summarizes the amendment at the next RSC committee meeting.

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Minor changes (such as room changes) are handled by EH&S as RUA **revisions**, and are approved by the RSO.

5-12 Supplementary Sources

The RSO uses a variety of references in recommending laboratory design or modification for the use of radioactive materials and/or radiation-producing machines. These references include:

CDPH published guidance
USNRC Regulatory Guides and NUREGS, i.e. NUREG 1556/V11
National Council on Radiation Protection
American National Standards/ Health Physics Society
International Atomic Energy Agency Safety Standards
Radiation Protection Dosimetry, publications
Peer reviewed books, journals and articles currently published.

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APPENDIX 6

Internal Dosimetry (Bioassay)

This Appendix provides additional information to that in Section 4.6, “Internal Radiation Dose” of the Radiation Safety Manual.

The need for bioassay is determined by a number of factors, including the isotope(s), the maximum activity at any one time, the chemical and physical form of the compound, and specific features of the laboratory in which the work is performed. In general, two types of routine bioassays are performed at UC Berkeley: (1) thyroid counts, for some users of high quantities of radioiodine, and (2) urine assays for screening of potential depositions. UC Berkeley will send bioassay to outside laboratories for baseline, routine and post exposure analysis and interpretation of results.

Bioassay is performed whenever an individual is likely to receive, in one year, an intake in excess of 10 percent of applicable limits. The RSO uses the “Table of Bioassay Criteria,” below, as a guide. Special procedures, containment systems, accident conditions, or other factors may affect the type and frequency of bioassay. The RSO reviews all special bioassay issues and makes the final determination of the bioassay requirement(s). Bioassay frequency may be reduced for operations that use an established procedure and for which bioassay results are consistently minimal or negative.

Personnel anticipating routine work that will require bioassay testing should contact EH&S RST for baseline tests. A final test should be done at termination of the exposure.

(a) **Table 11: Bioassay Criteria**

Type of Exposure	BIOASSAY	Frequency
More than 50 mCi per week of any unsealed radioisotope (except radio-iodine).	Urinalysis	Monthly
More than 100 mCi per use of H-3.	Urinalysis	Weekly
More than 10 mCi per month of volatile or dispersible radioisotopes (except radio-iodine).	Urinalysis	Monthly
Single use of more than 25 mCi of any non-volatile compound, or of more than 10 mCi of a volatile or dispersible compound (except radio-iodine).	Urinalysis	Spot check within two (2) days of use
More than one (1) mCi per quarter of non-volatile radio-iodine compound, or of more than 0.1 mCi of volatile radio-iodine compound.	Thyroid scan	Quarterly
More than 10 mCi (at one time or cumulatively over one month) of volatile radio-iodine compound or of more than 100 mCi of non-volatile radio-iodine compound.	Thyroid scan	Within 24–72 hours of use
If it is known or suspected that there has been an uptake of radioactive material.	As appropriate	Within 24–72 hours of use.

APPENDIX 7

External Dosimetry

This Appendix provides additional information to that in Section 4.5, "Personnel Monitoring", of the *Radiation Safety Manual*.

Dosimetry recommendations are based on the isotope(s) and maximum activity handled during any one year (assuming the actual handling time is less than one hour), or on the type of machine X-ray source. A table of external dosimetry recommendations is shown on the following page. The RSO is responsible for reviewing all special dosimetry issues, and may use professional judgment and experience to modify (individualize) recommendation for a particular RUA. The RSO makes the final determination of required dosimetry.

Table 12: External Dosimetry Requirements as a Function of Likely Dose

Dosimetry is required if an adult is likely to receive in one year a dose greater than:

Type of dose:	Dose per year:
Deep dose equivalent	500 mrem/y
Eye dose equivalent	1,500 mrem/y
Shallow dose equivalent to the skin	5,000 mrem/y
Shallow dose equivalent to any extremity	5,000 mrem/y

Dosimetry is required if a minor is likely to receive an annual dose greater than:

Type of dose:	Dose per year:
Deep-dose equivalent	100 mrem/y
Eye dose equivalent	150 mrem/y
Shallow dose equivalent to the skin	500 mrem/y
Shallow dose equivalent to any extremity	500 mrem/y

Dosimetry is required for declared pregnant women who are likely to receive a dose from occupational exposures in excess of 100 mrem for the entire gestation period.

Dosimetry is required for all individuals permitted to enter a high radiation area.

If the RSO's prospective evaluation shows that the individual is not likely to exceed these dose values, there are no record keeping or reporting requirements in regard to the individual's exposure. However, if the prospective evaluation shows that the individual is likely to exceed these values, then monitoring and reporting of the results of monitoring, is required. This requirement for monitoring and documentation will continue to apply, regardless of the results of the recorded by dosimeters used by the individual (i.e. the requirement is based on the determination that the individual is likely to exceed the threshold dose values).

Dosimetry requirements are specified on the RUA. Most external dosimetry is assigned to a **specific individual** and may not be used by anyone else. (In some cases, the RSO may choose to use “area badging” rather than badging individuals; this decision is documented in the RUA file.) Dosimetry must be worn whenever there is a potential for exposure. When not in use, dosimeters should be stored away from moisture, heat, and radiation. All dosimeters must be returned to EH&S upon request, and for routine exchange at the time specified when the dosimetry was issued. Notify EH&S of any occurrence that might affect the results, such as contamination, improper storage, x-rays, etc. The RSO investigates all lost or discrepant dosimetry, and any discrepant results.

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Incoming dosimetry reports are reviewed by the RST and RSO, who will determine what, if any, further review or investigation may be needed. If results indicate the recommendations in the following table are not adequate to ensure compliance with the monitoring requirements, the RSO will revise the Table.

Some environmental monitoring is performed to demonstrate that dose to members of the public is a small fraction of the 100 mrem/year limit. The RSO ensures this dosimetry is placed and periodically read to optimize the minimal detectable dose.

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Table 13: Guidelines for External Dosimeter Assignment

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(See following page for footnotes)

Type of Radiation Source	Threshold for External Dosimeter Requirement (total activity used by person in 12-month period) ^{1,2,3}	Type of External Dosimeter Required	Dosimeter Exchange Frequency
For Radioactive Materials:			
³ H, ¹⁴ C or ³⁵ S	Not Applicable	None	Not Applicable
Beta emitters below 0.5 MeV—except ³ H, ¹⁴ C or ³⁵ S	20 mCi	Finger ring	Approximately every four months
	200 mCi	WB ⁴ badge	
Beta emitters with maximum beta energy of 0.5 MeV or greater	10 mCi	Finger ring	Approximately every four months
	100 mCi	WB badge	
Gamma emitters if dose rate in mR/hr per mCi at 1 meter is: <u>1.0 or more</u> <u>0.5 to 0.99</u> <u>0.2 to 0.49</u> <u>0.1 to 0.19</u> 0.09 or less	<u>1 mCi</u> <u>2 mCi</u> <u>5 mCi</u> <u>10 mCi</u> 20 mCi	Finger ring	Approximately every four months
Gamma emitters if dose rate in mR/hr per mCi at 1 meter is: <u>1.0 or more</u> <u>0.5 to 0.99</u> <u>0.2 to 0.49</u> <u>0.1 to 0.19</u> 0.09 or less	<u>10 mCi</u> <u>20 mCi</u> <u>50 mCi</u> <u>100 mCi</u> 200 mCi	WB badge	Approximately every four months
Neutron emitters (moisture probes, PuBe, AmBe, PoBe, RaBe sources, etc.)	Dosimeter required if person's dose likely to be > 10% of regulatory dose limit.	WB badge with neutron dosimeter	Approximately every four months

Guidelines for External Dosimeter Assignment, cont'd

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Type of Radiation Source	Threshold for External Dosimeter Requirement (total activity used by person in 12-month period) ^{1,2,3}	Type of External Dosimeter Required	Dosimeter Exchange Frequency
For Radiation Producing Machines (RPMs):			
X-ray diffraction/fluorescence and cabinet X-ray units	Not Applicable	Finger ring	Approximately every four months
Electron Microscopes	Not Applicable	None	Not Applicable
Medical X-ray Machines	Not Applicable	WB badge ⁵	Monthly
Veterinary X-ray machines	Not Applicable	WB badge ⁵	Approximately every four months
Neutron generators (e.g. accelerators that emit neutrons by design or as secondary radiation).	Dosimeter required if person's dose likely to be > 10% of regulatory dose limit.	WB badge with neutron dosimeter	Approximately every four months

Footnotes:

1. For radioactive materials use, the threshold cumulative activity corresponding to when external dosimeter will **generally** be required. The Radiation Safety Officer (RSO) MAY require external dosimeter use at other cumulative activities or may require use of additional dosimeters; if you are a radiation user and already listed on an RUA, note any dosimetry requirements specified for you by the RUA.

2. Minors and "declared pregnant women" are to use external dosimeters at cumulative activities that are 10% those listed in the table OR as directed by the RSO.

3. If more than one isotope is to be handled during the year, for each isotope, divide the amount to be handled by the amount in the table and sum the fractions for all isotopes authorized. If the sum of the fraction is greater than 1, require the use of the specified external dosimeter.

4. WB = Whole Body

5. Users of medical/veterinary x-ray machines must avoid having their hands in the diagnostic field during x-ray exams.

APPENDIX 8

Responsibilities of the Radiation Safety Officer (RSO)

This Appendix provides additional details as to responsibilities of the RSO from Section 2.4.2, “Radiation Safety Officer” of the *Radiation Safety Manual*.

8-1 Regulations and Agency Interactions

The Radiation Safety Officer (RSO) is responsible for:

- ❑ Interpreting and communicating federal/state requirements for the campus.
- ❑ Acting as liaison between UC Berkeley and federal/state regulatory agencies.
- ❑ Maintaining records of radiation-safety operations for inspection by various agencies.
- ❑ Making the initial determination as to whether to report a program deficiency or radiation incident to federal/state agencies.
- ❑ Maintaining UC Berkeley Radiation Safety Program files of federal, state, and local licenses, registrations, and records.
- ❑ Being familiar with federal, state, and local radiation-safety regulations and proposed changes.
- ❑ Informing the RSC, EH&S and others as appropriate and campus management when regulatory changes require or suggest modification of the campus Radiation Safety Program, Radioactive Materials License, *RSM*, or campus radiation safety policy.
- ❑ Ensuring that the license is kept current and that amendment and renewal requests are submitted as needed.
- ❑ Developing, implementing, and documenting corrective actions for regulatory violations.

8-2 Compliance Assurance

The RSO:

- ❑ Ensures that an audit of the campus radiation-safety program is performed at least annually and documented.
- ❑ Ensures that the requirements of Title 17 CCR and the campus Radioactive Materials License are met.
- ❑ Develops, publishes and revises the campus RSM, and obtains RSC and other needed reviews and approval of all changes to the manual.
- ❑ Monitors campus radiation uses, and provides radiation-safety services that conform to policies and standards set by the Nuclear Regulatory Commission (NRC), the State of California, and the RSC, and documented in the RSM.

- ❑ Reviews radioactive waste disposal activities.
- ❑ Reviews applications for new and modified uses of radioactive materials or RPMs prior to their use.
- ❑ Reviews projects and inspects facilities to determine the level of compliance with pertinent regulations and conditions specified by the RUA.
- ❑ Investigates problems, develops corrective actions, reports to the campus management and RSC (as necessary), and verifies implementation of corrective actions.
- ❑ Along with other EH&S steps, provides radiation-safety services including (1) personnel and area monitoring, (2) instrument calibration, (3) waste disposal, (4) facility design and project planning, (5) package inspection, and (6) training.
- ❑ Maintains appropriate records of radiation safety operations for inspection by various agencies.
- ❑ Conducts training.
- ❑ Verifies that sealed sources are leak-tested at required intervals.
- ❑ Assures an inventory of all radioactive materials on campus is maintained. (The RSO ensures that the campus license limits for these materials are not exceeded by use of the Radiation Safety Information System (RSIS).
- ❑ Verifies that each radioactive-materials user maintains an inventory of the types and quantities of radionuclides at each facility (the RSO ensures an annual inventory is performed and verifies that these are limited to the forms and amounts authorized by the RUA).
- ❑ Ensures an annual inventory of source and special nuclear material is performed and maintains the Nuclear Materials Management and Safeguards System.
- ❑ Ensures an annual inventory of nationally tracked radioactive material sources is conducted and maintains the National Source Tracking System. 3
- ❑ Verifies that campus radioactive effluents are measured, monitored, and controlled as needed.
- ❑ Monitors implementation of the Radiation Safety Program through periodic site visits.
- ❑ Ensures that required surveys are performed.
- ❑ Ensures that vendor-provided dosimetry reports are periodically reviewed, and that issues needing correction are addressed.
- ❑ Verifies that licensed radioactive materials are reasonably secured from theft or misuse.
- ❑ Ensures that the Increased Controls Program is established, implemented and maintained. 3
- ❑ Ensures that packaging, transport, and receipt of radioactive material are in accordance with applicable Department of Transportation (DOT) and other agency requirements.

8-3 Relation to the Radiation Safety Committee (RSC)

With regard to the RSC, the RSO:

- Is a member.
- Ensures that RSC committee minutes and records are maintained.
- Coordinates implementation of RSC assignments.
- Provides technical support to the committee.
- Calls emergency meetings as needed to address urgent radiation-safety issues.
- Reports on radiation-safety matters including any issues that may place campus personnel or the public at risk.
- Reviews and reports on the effectiveness of EH&S Radiation Safety operations and procedures.
- Verifies that campus users of radioactive materials adequately and promptly resolve radiological issues, and reports failures to resolve problems to the committee or its Chair.
- Obtains RSC review and approval of all changes to the RSM or campus license.

8-4 Radiation Use Authorization (RUA) program

The RSO:

- Reviews and approves all initial RUAs and renewals prior to delivery of radioactive materials to the users, or prior to start of use.
- Interviews RUA applicants and inspects the proposed workplace(s) based on the level of radiological hazard associated with the RUA.
- Develops, distributes, and implements up-to-date radiation-protection procedures used in the daily operation of the licensee's radiation safety and control program.
- Ensures that possession, use, and storage of licensed material are consistent with the limitations in the license, the regulations, the Sealed Source Device Registration Certificate(s), and the manufacturers' recommendations and instructions.
- Ensures that individuals installing, relocating, maintaining, or repairing sealed-source devices are trained and authorized.
- Ensures that personnel have training commensurate with their duties regarding licensed material.
- Serves as the primary source of radiation-protection information for personnel at all levels of responsibility.

The RSO also reviews and/or monitors the following elements of each project before approval:

- ❑ The campus inventory of radioactive materials
- ❑ The registration of RPMs
- ❑ The need for bioassay (and, if conducted, bioassay results)
- ❑ Dosimetry needs and personnel exposure results and reports
- ❑ The need for inspections (surveys) and methods, and the resulting reports
- ❑ Shipments of radioactive materials
- ❑ Non-routine disposal of radioactive wastes

8-5 ALARA Compliance

The RSO is responsible for ensuring that UC Berkeley radiation exposures to on- and off-campus personnel and members of the public are as low as reasonably achievable (ALARA). Specifically, the RSO:

- ❑ maintains documentation to demonstrate (1) that workers are not likely to receive, in one year, a radiation dose in excess of 10 percent of the allowable limits, or (2) that personnel monitoring devices (dosimeters) are provided; and 3
- ❑ maintains documentation to demonstrate, by measurement or calculation, that the total effective dose equivalent (TEDE) a member of the public is likely to receive from the licensed operation does not exceed the annual Nuclear Regulatory Commission (NRC)/Department of Public Health (CDPH)/campus limit for members of the public (100 mrem per year). 3

8-6 Emergency Response

The RSO helps coordinate emergency response activities involving radioactivity and ensures that response plans are developed and implemented as needed.

8-7 Radiation Incidents

The RSO classifies each radiation incident as “major” or “minor.” Major incidents are those that require reporting to a regulatory agency. Minor incidents need only be reported to the RSC. For each occurrence, the RSO prepares a comprehensive incident report and sends copies to the individual(s) involved, the RUA Holder (RH), the Department Chair, and the RSC.

8-7.1 Major incidents

Major incidents are those requiring notification of either state or federal regulatory agencies, and are defined in the respective regulations. Major incidents must be reported by telephone or in writing by the RSO to either CDPH or the NRC. Incidents involving state licensed items are reported as specified in 17 CCR §30294, §30295, and §30297. Federally licensed items are reported as specified in 10 CRF §20.2201, §20.2202, and §20.2203. Copies of reports are provided to the RH and the RSC. Major incidents include any the following: 3

- Theft or loss of any RPM or of any quantity of radioactive material in excess of regulatory limits.
- A dose in excess of any regulatory limit.
- Levels of radiation or concentrations of radioactive materials in excess of the applicable reporting limits set by the state or NRC.
- Unplanned contamination events in excess of incident reporting criteria.
- Safety related equipment fails to function such that dose or release limit could have been exceeded.
- Unplanned medical treatment of a contaminated individual.
- Fire or explosion damaging licensed material or its storage container.

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8-7.2 Minor Incidents

Minor incidents are those in which the internal or external exposure, area contamination, or other factors require documentation and review by the RSC, but for which no regulatory notification is mandated or required. Minor incidents include any of the following:

- Area contamination that results in traffic restrictions, considerable decontamination, or significant inconveniences for less than 24 hours as determined by the RSO.
- Levels of radiation or concentrations of radioactive materials in uncontrolled areas of **less than** 10 times the applicable reporting limits set by the state or NRC. (See table 1, page (18) of the *Radiation Safety Manual* for regulatory limits.)
- Detectable skin contamination that cannot be immediately removed or significant internal deposition of radioactive material.
- A combination of events that results in situations that the RSC, the parties involved, and/or others working with radiation should be aware of and avoid in the future.

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8-8 Stop-Work Authorization

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.

RADIATION PROCEDURE CHANGE HISTORY

REVISION HISTORY					
ASSIGNED RST Member Name	Version Number	DESCRIPTION Reason for revision (Attach additional sheets if needed)	DATE Revision Assigned	DATE Revision Due	DATE APPROVED
Greg Yuhas	1	Change in radiotoxicity factors	Memo date	NA	Dec. 2, 2008
Greg Yuhas	2	Administrative corrections and changes to ensure compatibility with regulatory requirements	NA	NA	March 18, 2009
Greg Yuhas	3	Change in RUA renewal and survey frequencies and numerous corrections and clarifications	August 21, 2009	Sept. 15, 2009	Sept. 15, 2009
Greg Yuhas	4	Delete use of radioactive materials in human research and minor changes	January 15, 2010	NA	March 15, 2010

CONTROLLED COPY DIST. LIST			
1	Approved RP File*	8	THE UNIVERSITY OF CALIFORNIA, BERKELEY EH&S Radiation Safety Team
2		9	
3		10	
4		11	
5		12	Title: RADIATION SAFETY MANUAL
6		13	Approval Authority: Radiation Safety Committee
7		14	

* The signed and approved copy of every RP is a controlled copy – to be maintained by the ARSO.