

# 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 fully comprehend 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 California Radiation Control Regulations and the UC Berkeley Broad-Scope Radioactive Materials License. Any changes to the campus radiation safety policies in the *Radiation Safety Manual* must be approved by the campus Radiation Safety Committee 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

The University of California, Berkeley (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 *Radiation Safety Manual (RSM)* has been prepared by the Radiation Safety Officer (RSO) and reviewed and approved by the Radiation Safety Committee (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 radiation hazard warning signs; and
- 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>) or hard copy of the *RSM* before a written “Radiation Use Authorization” (RUA) is approved, and on publication of revised editions. A copy of the manual must be available for reference in every laboratory in which sources of ionizing radiation are used.

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 are evaluated through the Radiation Protection Program audit process.

Non-intent 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.

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

UC Berkeley will establish, implement, and maintain procedures, instructions, and notices necessary to implement the *RSM and IC* 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.

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## 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.

### 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.

### 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 surveillance over the program and provides periodic program status reports to the VCR. Surveillance activities include the review and approval of radiation-use applications and the review of EH&S radiation safety and radioactive waste related operations.

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

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 surveillance of all users of radioisotopes and/or Radiation Producing Machines (RPMs) and equipment. 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 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. 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 Purchasing Department**

The Purchasing Department is responsible for acquiring both radioactive materials and RPMs only from authorized vendors using authorized methods. The RSO works with Purchasing to ensure that those individuals requisitioning radioactive material are authorized to receive, possess, and use it.

## **2.6 Department Chairs and Unit Directors**

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

## 2.7 RUA Holder

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

- ❑ ensuring that the laboratory (or other work area) is safe for use by personnel, including the radiation user(s);
- ❑ ensuring that anyone permitted to work with or in proximity to sources 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,
- ❑ 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.

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

## 2.8 User

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 required by the *RSM* and the RH for their 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.

See appendix E for details.

## **2.9 Ancillary Personnel**

Ancillary personnel include workers (maintenance or other) who are temporarily assigned to perform work in areas listed in a RUA but who will not work with radiation 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. These workers receive basic radiation safety training, but are not normally considered to be occupationally exposed radiation workers.

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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 California Department of Public Health (CDPH) has 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

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.

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 sources of ionizing radiation (materials and/or 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 consumer products containing radioactive material (e.g., 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 a Radiation Use Authorization (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 statement of the Standard Operating Procedure (SOP) (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 RSO conducts 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 need 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
- ❑ 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, a copy of the signed RUA is sent to the RH, and work involving radiation may begin.

### 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)

Note: Certain sources of radioactive materials require increased controls to satisfy state and federal requirements. These controls are stipulated in the UC Berkeley Increased Controls Plan and in certain Radiation Safety Procedures. Contact the RSO to determine if the radioactive materials you intend to use are considered special nuclear material, a source requiring increased controls, or as a part of the National Source Tracking System. If the radioactive material meets one or more of these criteria the Radiation Safety Team will advise the applicant of the additional controls 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 example, certain sources must be controlled in accordance with the UC Berkeley Increased Control Plan while 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".

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### 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. See appendix G for more information.

### 3.2.4 Application for Use of Radiation in Humans

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

See appendix G for more information.

### 3.2.5 Application for use in the Field

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.

Note that 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.

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

Any change to or modification of an existing RUA must be reviewed and approved before implementation. Amendments to approved RUAs may be requested at any time by contacting the RSO or an EH&S Radiation Safety staff member.

Requests for minor RUA changes may be approved by the RSO. Significant changes may require approval of the RSC or the RSC Chair. The RSO determines the level of review required.

### 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 two 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.

### 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.

### 3.7 EH&S Radiation Safety Surveys

Periodically, Radiation Safety staff in EH&S 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.

The DHS 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.

These surveys are performed to determine if operations are being conducted properly and safely. Specifically:

- Are radioisotopes used in accordance with the conditions of the RUA and RSM?
- 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 prepare a survey report detailing the issue(s) and the needed corrective action(s). The RSO reviews all reports of problems, determines what action(s) must be taken, and sets the date by which corrective action must be completed. The report is sent to the RH and a copy is placed with the EH&S records for the laboratory.

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. 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 Radiation Safety Organization played in regard to implementation of the Radioactive Materials License conditions.

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 their research.

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 EH&S 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.

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 for disposal. Contact EH&S for specific termination instructions.

#### 3.8.1 Termination of Use of Facilities and Equipment

Once an area has been under an RUA, it cannot be transferred to unrestricted use for other purposes until EH&S 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 EH&S will provide technical assistance and supervision if available.

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

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 Radiation Safety Team well in advance of plans to terminate use of a building or offsite use location.

### 3.9 Medical Monitoring and Examination Requirements

The RSO has the authority to require that a user of any source of radiation submit to a medical examination, including bioassay and medical monitoring (described in section 4.5 of this manual). Based on a variety of issues, the RSO determines any examination requirements.

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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 required by federal and state regulations.

### 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 Nuclear Regulatory Commission (NRC)/ CDPH limits specified in table 1, below.

**Table 1. Occupational Dose Limits** (external and internal sources added together)

Category of Dose Equivalent	Regulatory NRC/DHS Limit <sup>1</sup>	UC Berkeley Administrative Guideline <sup>2</sup>
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

<sup>1</sup> Regulatory limits are legal dose equivalent limits adopted by the NRC and/or DHS.

<sup>2</sup> Administrative 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 NRC/DHS limits above.

### 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 NRC/CDPH 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/DHS Limit*	UC Berkeley Administrative Guideline*
Annual Limit	100 mrem/yr	10 mrem/yr
Exposure in any one hour	2 mrem/hr	0.2 mrem/hr

\* See note under table 1 on previous page.

#### 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 document stating her pregnancy status, the estimated date of conception and/or due date, student or employee number, and the RUA number under which she is working.

The decision to declare pregnancy is completely voluntary on the part of the worker. However, a worker who chooses not to declare her pregnancy is neither subject to nor protected by the provisions for workers 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 worker who has declared her pregnancy may decide what level of risk to accept; she may choose a level of risk lower than the regulatory limit.

The RSO’s review of the potential exposures the worker faces may result in work modifications of the use of special dosimetry.

##### 4.4.2 Resources for Pregnant Workers

The NRC’s Regulatory Guide 8.13, “Instruction Concerning Prenatal Radiation Exposure,” as well as associated supplements and additional information on risks and choices, can 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.

Additional details are found in Appendix I, “Special Information for Pregnant Workers.”

## 4.5 Personnel Monitoring for Exposure to Ionizing Radiation (Dosimetry)

### 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 NRC/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 specific use(s) described on the RUA before work begins. Based on the RSO’s review, dosimetry requirements are determined and are noted 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 EH&S.

### 4.5.3 Proper Use of Dosimeters

All users of dosimetry must comply with these guidelines:

- ❑ Wear dosimeter(s) when working with radiation or radioactive material.
- ❑ Wear monitors correctly: **Whole-body badges** are normally worn on the belt or at chest level. **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.
- ❑ Store dosimeters away from sources of radiation and environmental extremes (e.g., moisture or heat).
- ❑ Exchange and return dosimeters as soon as possible after the replacements arrive.
- ❑ Use only the dosimetry that was provided to you.

## 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 users of high levels of tritium. 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 open (uncontained) materials or work in the vicinity of materials being used at greater than 10 percent of NRC/CDPH limits.

If a measurable amount of radioactive materials is found by bioassay of an individual, the RSO will take action to 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 ( $\geq 100$  mrem) in a dosimetry reporting period (typically a period of 4 months)

Extremity doses registering  $\geq 500$  mrem in a reporting period (typically a period of 4 months)

If the reading is accurate, review helps determine the cause and address the reduction of future exposures.

### **4.7.1 Routine ALARA Exposure Reviews**

EH&S staff 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 dose. 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.

**NRC/CDPH Limits**

In the case of known or suspected overexposures (exposures exceeding NRC/CDPH limits), the RSO notifies the CDPH. The RSO/RSC may require personnel to 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 EH&S for action. EH&S Radiation Safety Team provides annual reports to all individuals receiving measurable dose that are on campus or have left forwarding addresses.

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## 5 AUTHORIZATION AND TRAINING OF PERSONNEL

### 5.1 Authorization

Users **must** be listed as authorized personnel on the RUA before beginning to work with radioactive materials or RPMs and have required training. Authorization does not mean “no supervision required.” All radiation work must be performed under the supervision of an RH or designee.

To be added to an RUA, each user must submit a Radiation User Information Record to the RSO, who reviews the information. A new user’s work with radiation is restricted until training requirements have been met.

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

### 5.2 Training

Radiation workers must be trained in the hazards they may encounter on the job and in methods to protect themselves 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 radiation-safety training.

The training program requires the following:

- ❑ All personnel who will be working with ionizing radiation will be trained to use it safely before beginning work
- ❑ EH&S staff will provide periodic general radiation safety training. Specialized training will be provided as needed or requested
- ❑ Some training must be performed by outside vendors. EH&S can provide information on vendor-provided training classes.

An annual refresher training program will be conducted for all RH’s, users, and ancillary personnel that frequent RUA areas. The focus of this refresher training is to review radiation safety requirements, discuss lessons learned from operational experience, and identify ways to reduce dose and improve performance. The annual refresher training will:

- ❑ Be tailored to specific groups, like the radiation safety team, radiation producing machine users, and radioactive material users,
- ❑ Include RH presentations to their RUA users and ancillary personnel,
- ❑ Include a test to evaluate the effectiveness of the training provided, and
- ❑ Be documented.

Retraining should also be conducted, at the discretion of the users’ supervisor, whenever there is a change in duties or the work environment and at a frequency sufficient to ensure that all staff are adequately trained.

## 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 approved RUA, which lists any specific requirements or conditions of use.
- ❑ A copy of this RSM. The manual must also be available to all designated users. (Access to the online version or other electronic copies is acceptable.)
- ❑ A copy of the SOP; see Appendix F.
- ❑ Copies of RUA surveys provided by EH&S.
- ❑ Documentation of training provided by the laboratory or others.
- ❑ Copies of the Radioactive Material Receipt and Use Log, detailing:
  - a. each receipt of isotope, its chemical and/or physical form, the quantity, and the date of receipt (including any radioactive materials transferred from one RUA to another); and
  - b. the date, activity, and use of each withdrawal from stock.
- ❑ Disposal records documenting the date, activity, physical form, and method of disposal of isotopes and contaminated lab material.
- ❑ A 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.

❑

## 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 Radiation Safety, which will determine needed actions and whether the incident must be reported to the state. 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 (642-3073). During off hours, call **911** 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** and ask for radiation safety assistance.

5. Prevent the spread of contamination by covering the spill with absorbent paper. (If solids are spilled, paper should be dampened.) Use absorbent paper as needed to clean up the spill.
6. Perform frequent surveys with an appropriate meter or machine to determine the effectiveness of the decontamination process.
7. During and after cleanup, carefully fold the absorbent paper with the clean side out and place in a labeled plastic bag. Put contaminated gloves and any other contaminated disposable material in the bag.
8. Survey the area with a meter or other appropriate technique. Check the area around the spill for residual (sometimes called “fixed”) contamination.
9. Survey all persons involved in the decontamination process; check hands, clothing, and shoes for contamination. Once personnel have been surveyed and found free of contamination, record their names and release them.
10. If personal contamination is detected, follow the procedure described above under “Personnel Contamination.”
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 (642-3073). During off-hours, call 911 and ask for radiation safety assistance.
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.



## **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 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 does the following:

- ❑ 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 radioactive materials located at UC Berkeley and associated facilities.
  - ❑ Supervises decontamination efforts.
  - ❑ Prepares new Radiation Use Authorizations (RUAs) and amendments for review by the RSO.
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- ❑ 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 of 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;
- ❑ 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.
- ❑ Maintaining records regarding:
  - radiation workers under the RH's jurisdiction;
  - receipt, use, and disposal of radioisotopes; and
  - monitoring of laboratories and workplaces, including contamination levels and exposure data; and
  - posting of RUA and other required forms/signs.
- ❑ Maintaining ongoing custody and security of any radioactive material or radiation-producing machines (RPMs) under the RUA.
- ❑ Having required records available for review by EH&S 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
  - return of personnel dosimeters
  - 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 radioactive materials being used.
  - B. Completion of EH&S-provided radiation safety training. This normally includes:
    - 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.

## 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, if required.
- ❑ 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.
- ❑ 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.
- ❑ 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.

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## **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 (an RUA) 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. Although each order is checked by EH&S staff when it arrives, please be aware of your RUA limits when ordering, so that receipt of your order is not delayed while a change to the RUA is reviewed and approved.

#### **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 radioactive materials inventory.

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

#### **F-3 Receiving Radioactive Material**

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

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

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 maintains records of radioisotope receipts.

Prior arrangements must be made for shipments that will not conform to the procedures described above.

#### 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.

#### 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 authorized personnel. 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.

#### 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.

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.

Someone in each laboratory should be responsible for periodically (visually) verifying the locations of all inventoried materials and checking that the records are kept current and accurate. Take care to ensure that the possession limit(s) do not exceed (by isotope and chemical form) what is allowed by the RUA.

Note: If source, special nuclear material, or nationally tracked sources are used, special inventory, physical protection, and reporting requirements apply. Contact the RSO for current procedures.

#### F-7 Posting Requirements for Radiation Laboratories

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

**At minimum**, all laboratories must post the following:

- 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>.
- Standard laboratory operating procedures (SOP).
- Emergency laboratory procedures and phone numbers.
- The RUA (at all entrances).

**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.**”

*Note:* Both these signs are available from EH&S.

## 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.

**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.

Note: Consumption of food and drink is strongly discouraged in laboratories, however, the RUA Holder may allow consumption in designated controlled areas of the laboratory. The establishment of any designated clean area within such a room requires the RUA holder to obtain formal written approval of the chair of the campus Radiation Safety Committee (RSC).

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 Radiation Safety team.

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:

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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.**

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**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 well below 0.2 millirems in any one hour. Total effective dose equivalent (TEDE) to any member of the public should be well below 10 mrem in any one year.

**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.
- ❑ 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 laboratory clothes over street clothes.
- ❑ 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 and forearms for contamination.
- ❑ 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:

- ❑ Pre-plan the operation in detail.
- ❑ 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 Self-Surveys

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 to detect or measure radioactive materials.

**Table 1. Recommended Radiation Detection Instruments**

<b>Radiation Type</b>	<b>Energy</b>	<b>Isotope example</b>	<b>Detector</b>
<b>Alpha</b>	All	Am-241, Cf-252	ZnS scintillation Proportional counter Wipe—LSC
<b>Beta</b>	< 200 KeV	H-3, C-14, S-35	Wipe—LSC
	≥ 200 KeV	C-14, S-35, P-33, P-32	Pancake GM Proportional counter Wipe—LSC
<b>Gamma</b>	< 200 KeV	Cr-51, I-125	Thin NaI scintillation Wipe—LSC
	≥ 200 KeV	Na-22, I-131	Thick NaI scintillation Wipe—LSC

### Survey Frequency

The frequency of user surveys is 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 table provides 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.

**Table 2 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

The frequency of user surveys is also based on relative radiotoxicity as defined in Table 3, below.

**Table 3 Survey Frequency by Relative Radiotoxicity**

Relative Radiotoxicity	Monthly	Weekly	Daily
4 – Very High	<10 $\mu$ Ci	10 $\mu$ Ci–1 mCi	>1 mCi
3 – High	<100 $\mu$ Ci	100 $\mu$ Ci–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

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### Survey records

Keep permanent written records of all survey results, **including negative results**. The surveys must include:

- Location, date, and equipment 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.
- Corrective action taken, if contamination or excessive exposure rates were found, and the reduced levels after corrective action.

### 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 Radiation Safety provides assistance or supervision in cases of gross or personal contamination.

## When decontaminating:

- ❑ Wear appropriate protective clothing (gloves, lab coats, etc.).
- ❑ Confine the spread of contamination, starting from areas of low contamination and working toward areas of higher contamination.
- ❑ 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.

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 4. UC Berkeley Contamination Limits**

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

	<b>Total (Includes removable and fixed contamination)</b>			
<b>TYPE OF SURFACE</b>	<b>dpm/100cm<sup>2</sup></b>	<b>α emitters dpm/100cm<sup>2</sup></b>	<b>β, X or γ emitters Radiotoxicity level 3, and 4 dpm/100cm<sup>2</sup></b>	<b>β, X or γ emitters Radiotoxicity level 1 and 2 dpm/100cm<sup>2</sup></b>
<b>Restricted and Controlled Areas</b>				
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*
<b>Unrestricted Areas</b>	
All surfaces, including items removed from restricted and controlled areas and “trash”	Not statistically different from background*

\*Background radiation is ambient radiation from the cosmos, from rocks and soil, or from  $^{40}\text{K}$  (radioactive potassium) in the body.

X = X-ray

$\beta$ , = beta

$\alpha$  = alpha

$\gamma$  = gamma

**Note:** 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.

## 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, pipets) 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  $^{14}\text{C}$  or  $^3\text{H}$  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.

## **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. (EH&S) 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, EH&S 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 Humans**

All research on humans requires permits from the Committee for the Protection of Human Subjects (CPHS). If human subjects will be exposed to radiation or radioactive materials, then both an RUA and approval by the CPHS are required. The RSO will start the authorization process, but does not complete the RUA or obtain required approvals until the CPHS has approved the human-use protocol.

On receiving CPHS approval, EH&S reviews the final protocol and obtains the required approvals from a subcommittee comprising the RSO, members of the RSC and CPHS, and a medical professional knowledgeable about the biological effects of radiation. Information related to the human use protocol is included on the RUA. No work with humans that uses radiation or radioactive materials can be performed without both CPHS approval and an RUA.

Additional information related to 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

### **General Regulations**

#### **H-1 Possession**

- ❑ Notify the Radiation Safety Officer (RSO) before bringing an RPM onto campus.
- ❑ 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.
- ❑ Notify the RSO before removing an RPM from campus.
- ❑ Notify the RSO if you deactivate an RPM. Label machines that are deactivated but left on campus with the words,  
**“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 State of CDPH as required.

#### **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.

### 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.

### 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.
- ❑ With the exception of mobile units, obtain prior approval from the RSO for any change in location of an RPM.

## 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 posted in the immediate vicinity of the machine that it was written for.

## 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

In addition, the RH or approved operator(s) must survey the machine for radiation leaks on the schedule specified on the RUA.

## 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.

## 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-kV/mA machines. The dosimeters are issued by EH&S, and must be worn as specified by the RUA.

## 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.
- Safety devices may **not** be purposely defeated, even when their use makes operating the machine difficult or impossible. If the design of a safety device prevents or inhibits operation, the RSO may approve an alternate safety device or method of equal protective value. (If safety devices are modified, it may be necessary to modify existing operating procedures or the RUA, and to retrain operators.)
- Do not operate a machine if a required safety device fails. Do not use the unit until it has been repaired and then checked by EH&S.
- Immediately notify EH&S if an unexpected personnel radiation exposure occurs or is suspected to have occurred. **Any overexposed dosimeter is considered presumptive evidence of exposure to the individual to whom the dosimeter was assigned.**

## 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 EH&S and to every user, and keep a copy available in the work area.

## 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
- 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 Medical machines**

- 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.

*Note:* All human-use machine operations, installation designs, etc., must be in accordance with published DHS 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
- Training including written test
- 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.

### **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.

### **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.

2

### **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 additional information to that found in Section 4.3, “Prenatal Radiation Exposure Policy,” of the *Radiation Safety Manual*.

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, as of which time she must be treated as a “declared pregnant worker.” Once that declaration has been made in writing, the worker may choose to limit exposures to the regulatory dose limits for a declared pregnant worker and her developing embryo/fetus.

#### 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:

- ❑ 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 EH&S if they have questions regarding radiation exposures during pregnancy. These calls, and the medical status of all individuals, are kept strictly confidential.

#### 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. RSO’s recommendations:

- ❑ Notify the RSO
- ❑ 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) mrems per hour or 10 mrems per week.
- ❑ The Radiation Safety Officer (RSO) determines if use of protective aprons may reduce exposure. Their use and effectiveness is determined in large part by the radiation that could be encountered. For example, thin lead aprons may be used for X-rays, but are not recommended for use with gamma emitters (such as Cr51) or high-energy beta emitters (such as P32). The Radiation Safety Officer (RSO) can advise the mother on the best combination of time, distance, shielding (such as 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 Radiation Safety team (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  $^{40}\text{K}$  (radioactive potassium) in the body.

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

**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  $3.7 \times 10^{10}$  disintegrations per second.

**declared pregnant worker.** A worker who has voluntarily informed the licensee, in writing, of her pregnancy and the estimated conception or due date. The declaration remains in effect until the worker withdraws the declaration in writing. [Title 10 CFR §20.1003 and Title 17, CCR]

**CDPH (Department of Public Health).** The California Department of Public Health

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

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

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

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

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

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

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

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

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

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

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

**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.

**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.

**Standard Operating Procedure (SOP).** See Appendix F.

**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]

**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
RUA	RADIATION USE AUTHORIZATION
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 two 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 and the Radioactive Drug Research Committee.

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 is incorporated by reference.

## 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 audits conducted in compliance with this manual. (Audit records are kept for at least three years.)
- 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.

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.
- 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 RSO prepares a draft RUA, defining the scope of the proposed radiation use. This draft includes classification, location, a listing of personnel, description of radiation use, limits of use, required work precautions, and personnel protective devices and dosimetry.

## **5-3 RUA Holder (RHs) Review**

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

## **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 draft RUA to an RSC member for review and approval. If the RSO discusses a Class I RUA with the RSC Chair, the Chair may 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.

### Class II (medium radiological hazard)

Following the RSO's review, the draft 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 denies 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.

### Class III (high radiological hazard)

Following the RSO's review, the draft RUA is submitted to the RSC for approval. Work cannot start until the RUA approval process has been completed and an approved RUA has been issued.

### Urgent or emergency RUAs

For Class I and II RUAs, the process is the same as above.

For Class III RUAs, the process is the same as above **except that** the application is submitted to the RSC (or a subcommittee of the RSC) for interim approval prior to an RSC meeting. The RUA is reviewed at the next committee meeting.

## **5-5 Renewal of RUAs**

RUAs are valid for a maximum of two 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.

If during the course of the renewal survey, or as a result of other sources of information, it 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 and inventory decay 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 radiation safety group 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 AU 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. (Addition)

## 5-6 Notification of Approval

The RSO files the approved RUA and distributes copies to the RH.

## 5-7 Additional Information

The following subsections describe how determinations are made regarding classification of radiation and radiation-producing machines 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 Hazard Guide Value is the sum of the highest individual HGVs for each listed radionuclide, experiment, order or possession unit and is calculated using this formula:

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

Where:

$Q_i$  = Quantity of a radionuclide in microcuries

$T_i$  = Relative Toxicity Factor

$U_i$  = Use Factor

$W_i$  = weighting factor for experiment, order, or possession

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

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**Factors used in HGV formula**

- a. Quantity of the radionuclide is expressed in microcuries.
- b. Relative Toxicity Factor 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.

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

1

### Additional $T_i$ Values for Isotopes According to Relative Radiotoxicity Per Unit of Activity<sup>1</sup>

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

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

- d. Weighting factor ( $W_i$ ) recognizes the change in risk associated with different phases of use:

Phase	Factor
Experimentation	1
Order handling	.1
Storage	.01

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.

### 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, survey meters are required for:

- ❑ Any use of unsealed gamma emitters and millicurie amounts of beta emitters of energy from 0.14 to 0.5 MeV, or any amount of beta emitters of energy greater than 0.5 MeV.
- ❑ Use of sealed sources larger than 1 millicurie.
- ❑ Use of selected X-ray diffraction or fluorescence machines, or other radiation-producing machines.

*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.

### 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 in the table 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 modified by the RSO based on compliance with conditions of use or use changes.

Periodically, EH&S performs surveys of radioactive materials–use labs. These surveys are categorized as:

- ❑ Routine (typically quarterly for use RUAs and once each six months for sealed-source-only RUAs)
- ❑ Renewal (typically not less than once every two years)
- ❑ Special
- ❑ Termination

### Details of the Radiation Safety Surveys

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

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.

### **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 radioisotope(s), their activity, 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
- 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**

Periodically, RUA Holders (RH) perform self-surveys of their own radioactive use. 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, Table 3 indicates general guidelines. Required survey frequencies may be modified at the discretion of the RSO or RSC.

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### **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 include:

- ❑ Repeated unnecessary exposure of personnel
- ❑ Repeated unnecessary contamination of work areas
- ❑ Non-reporting of spills or suspected high exposures
- ❑ Non-reporting of required RUA changes (such as isotope or personnel)
- ❑ 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
- ❑ 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 thereunder must be accounted for to the RSO. Remaining materials must be transferred to another RH who has been authorized to receive them, or disposed of as radioactive waste.

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

- ❑ termination survey
- ❑ return of personnel dosimeters
- ❑ removal of radiation-hazard warning signs
- ❑ removal of radioactive waste
- ❑ removal or transfer of radioactive materials

### **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 by more than 10 percent, 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 RSC. Normally, the RSO reviews and summarizes the information for the RSC and presents it at the next committee 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 approved on an interim basis by the RSO and discussed at the next RSC meeting.

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:

“Radiation Protection Procedures,” International Atomic Energy Agency (IAEA) Safety Series No. 38, International Atomic Energy Agency, Vienna, 1973.

“The Handling, Storage, Use and Disposal of Unsealed Radionuclides in Hospitals and Medical Research Establishments,” International Commission on Radiological Protection (ICRP) Publication 25, Pergamon Press, 1965.

“Report of Committee V on the Handling and Disposal of Unsealed Radionuclides in Hospitals and Medical Research Establishments,” ICRP Publication 5, Pergamon Press, 1965.

American Standard, “Design Guide for a Radioisotope Laboratory (Type B),” American National Standards Institute, New York, N5.2-1963.

*Handbook of Laboratory Safety*, N.V. Steere (ed.), The Chemical Rubber Company, Cleveland, Ohio, 1967.

## 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 users of high levels of tritium.

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 Radiation Safety for baseline tests. A final test should be done at termination of the exposure.

(a) Table of 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 requirements are based on the isotope(s) and maximum activity handled at any one time, or on the type of machine X-ray source. A table of external dosimetry requirements 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) requirements for a particular RUA. The RSO makes the final determination of required dosimetry.

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, dosimetry 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, etc. The RSO investigates all lost or discrepant dosimetry, and any discrepant results.

Incoming dosimetry reports are reviewed by the RSO, who determines what, if any, further review or investigation may be needed.

Table of External Dosimetry Requirements

Type of Exposure	Maximum Activity (in mCi)	Dosimetry Required <sup>1</sup>	Exchange Frequency		
C14, S35, H3	Any	None	N/A		
Beta emitters below 0.5 MeV—except C14, S35, and H3	20 mCi 200 mCi	Finger ring WB <sup>2</sup> badge	Approximately every four months.		
Beta emitters above 0.5 MeV	10 mCi 100 mCi	Finger ring WB badge	Approximately every four months.		
Gamma emitters mR/hr per mCi at one (1) m  1.0 or more 0.5 to 0.99 0.2 to 0.49 0.1 to 0.19 0.09 or less	1 mCi 2 mCi 5 mCi 10 mCi 20 mCi	Finger ring	Approximately every four months.		
	10 mCi 20 mCi 50 mCi 100 mCi 200 mCi	WB badge			
	X-ray diffraction/fluorescence and cabinet X-ray units	N/A		Finger ring	Approximately every four months.
	Electron Microscopes	N/A		None	N/A
	Medical X-ray Machines	N/A		WB badge	Monthly
	Veterinary X-ray machines	N/A		WB badge	Approximately every four months.
	Neutron sources such as moisture probes, PuBe, neutron generators, etc.	N/A		Neutron Beta/Gamma WB	Approximately every four months.
	Accelerators	N/A		As indicated on RUA	Approximately every four months or as on RUA
Other uses on RUA	As on RUA	As on RUA	As on RUA		

1. Minors and “declared pregnant workers” are issued dosimetry at 10% of the above or as directed by the RSO.

2. WB = Whole body

## **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 verifies that the campus license limits for these materials are not exceeded).
- ❑ Verifies that each radioactive-materials user maintains an inventory of the types and quantities of radionuclides at each facility (the RSO verifies that these are limited to the forms and amounts authorized by the RUA).
- ❑ 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 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).
- ❑ 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 is 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;
- ❑ 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 Health Services (DHS)/campus limit for members of the public (100 mrem per year); and

## 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 DHS 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:

- 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.

### 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.

### **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.

