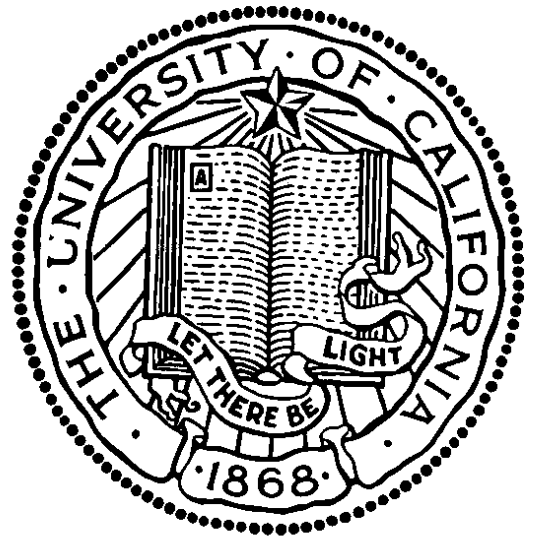


# Radiation Safety Manual

*University of California, Santa Cruz*  
Environmental Health & Safety



**In Case of Emergency Dial 911**

For Information Call EH&S Radiation Safety - (831) 459-2553

June 2001



# RADIATION SAFETY MANUAL

UNIVERSITY OF CALIFORNIA, SANTA CRUZ

## FOREWORD

Many research and instruction activities involve the use of ionizing and non-ionizing radiation as a valuable tool to extend fundamental knowledge and they are an important part of the University's contribution to the society it serves.

The safety record of the University of California Santa Cruz in its use of such radiation attests to the success of the radiation safety program. Safety standards must continue to be met.

This manual describes the policies and procedures established to ensure radiation safety on this campus. All personnel working with ionizing and non-ionizing radiation are required to fully comprehend and follow policies and procedures set forth herein. They must also exercise proper care to prevent radiation from becoming a hazard to themselves or others.

The use of radioactive materials and radiation producing machines is governed under the California Radiation Control Regulations and the UCSC Broad Scope Radioactive Materials License. This document details how the appropriate state and federal regulations (see Appendix A) will be applied at UCSC. This Radiation Safety Manual supersedes all previous documents and procedures.

Any changes to the policies and procedures included in the Radiation Safety Manual must be approved by the Radiation Safety Committee before implementation. Radiation users will receive updates from EH&S Radiation Safety when changes have been made.

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Chancellor

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## 1 UCSC RADIATION SAFETY POLICY

The University of California, Santa Cruz (UCSC) has a moral and legal obligation to establish work practices that provide a safe and healthful environment for students, employees, and the public who participate in official campus activities.

Because of potential hazards involved in the use of radioactive materials and radiation emitting devices, the campus administration recognizes the need for a Radiation Safety program. It is the policy of UCSC to implement a Radiation Safety program that maintains the level of exposure to employees, students and the public, "As Low As Reasonably Achievable" (ALARA).

The program is intended to protect personnel from unnecessary radiation exposure, to prevent contamination of our natural resources and to meet the state and federal regulations governing the possession and use of radioisotopes and radiation producing sources. To this end, this Radiation Safety Manual has been prepared with approval by the Chancellor.

The Radiation Safety Manual establishes procedures and regulations governing the safe use of sources of radiation at UCSC that conform to the guidelines, standards, and regulations set forth by pertinent sections of the and the Code of Federal Regulations (CFR) and the California Administrative Code (CAC). See Appendix A for listing of federal and state regulations and statutes.

Every Radiation Principal Investigator (RPI), will be issued a copy of the Radiation Safety Manual at the time of its publication and/or when a "Radiation Use Authorization" (RUA) is approved. A copy of the Radiation Safety Manual shall be kept in the laboratory where sources of ionizing radiation are used and shall be made available as a reference to persons involved with the project(s).

The Radiation Safety Committee and the Radiation Safety Officer are authorized by the Chancellor to limit, suspend, or revoke an individual's authority to use radioactive material(s) or sources of ionizing radiation if such use is dangerous to the life and health of individuals, or violates health and safety codes.



## 2 ORGANIZATION AND RESPONSIBILITY

For the Radiation Safety Program to function effectively it is necessary that each individual involved understand and perform their responsibilities. These are as follows:

### 2.1 Chancellor

Through the University of California policy on Environmental Health and Safety, the Chancellor is responsible for the existence of a radiation safety program that will maintain compliance with relevant local, state, and federal regulations related to the use of ionizing radiation. The Chancellor has delegated responsibility for development/operation of the radiation safety program to the committees, departments, and individuals as stated below.

### 2.2 Radiation Safety Committee

The Radiation Safety Committee (RSC) is a body of faculty and other experts appointed by the Chancellor to establish policies and procedures governing the use of ionizing radiation at UCSC, to maintain surveillance over activities involving them, and to report on their status to the chancellor. Surveillance activities include the review and approval of use applications and the review of EH&S Radiation Safety operations.

*Refer to Appendix B for RSC Bylaws.*

### 2.3 Office of Environmental Health and Safety

The Office of Environmental Health and Safety (EH&S) implements the radiation safety program. This program includes surveillance of all users of radioisotopes and/or radiation producing machines and equipment. Specific functions include: monitoring of exposure levels, investigation of incidents, safety consultation, training in radiation safety, radiation safety services, and management of radioactive wastes.

*See Appendix D for details.*

#### 2.3.1 The Director of Environmental Health and Safety

The director is responsible for the review of UCSC policies on radiation and radiation safety. The EH&S Director is responsible for reviewing UCSC performance regarding policies and procedures on radiation safety, and ensuring that the university administration is adequately informed of its responsibilities on matters related to radiation safety. The EH&S Director is an ex-officio member of the RSC.

#### 2.3.2 The Radiation Safety Officer (RSO)

The RSO is responsible for operation of the radiation safety program and for ensuring that radiation uses are in conformance with UCSC policies and applicable government regulations. The RSO is also responsible for referring to the RSC matters requiring its review and approval. The RSO is an ex-officio member of the RSC.

*See Appendix C for details.*

### 2.4 Purchasing Manager

The Material Manager is responsible for the acquisition, through established procedures, of all radioactive materials and equipment capable of producing ionizing radiation. EH&S Radiation

Safety will assist Material Management in determining if the individual requesting any radioactive material or radiation producing machine is authorized to use and possess it.

## **2.5 Deans, Department Chairs, and Administrative Officers**

Deans, Department Chairs and Administrative Officers are responsible for the review and approval of proposed uses of radionuclides and radiation producing machines within their jurisdiction. Such approval signifies that the department will provide the resources, including facilities and equipment, necessary to control hazards and will establish, as departmental policy, the procedures required to comply with applicable campus and governmental standards and regulations.

## **2.6 Radiation Principal Investigator**

The Radiation Principal Investigator (RPI) is the individual who has applied for and received an authorization from the Radiation Safety Committee to use radioactive materials or radiation producing machines. Each RPI is responsible for:

1. Ensuring that the laboratory environment is safe for use by the Designated User(s) (DU).
2. Maintaining compliance with local, state, and federal regulations.
3. Adhering to the conditions of this Radiation Safety Manual and their Radiation Use Authorization (RUA).

*See Appendix E for details.*

Individuals who are proposed as Radiation Principal Investigators must have minimum qualifications as follows:

1. Be a faculty member of the University of California, Santa Cruz.
2. Possess a college degree or an equivalent in the physical or biological sciences or engineering.
3. Have at least 40 hours of training or practical experience in the characteristics of ionizing radiation and its radiation dose quantities, radiation detection instrumentation, and biological hazards of exposures to radiation appropriate to the types and forms of radiation sources to be used.

## **2.7 Designated User**

The Designated User (DU) is an individual who is listed as a user on a Radiation Use Authorization. Each DU is responsible for their own safety and the safety of those around them. Each DU is responsible for:

1. Keeping radiation exposures "As Low As Reasonably Achievable" (ALARA).
2. Knowing and observing precautions specified in the Radiation Safety Manual and the specific requirements of the RUA involved.
3. Informing the RPI and/or RSO of any unsafe conditions known to exist.

*See Appendix F for details.*

## **2.8 Ancillary Personnel**

This category includes those workers, maintenance or otherwise, who are assigned temporary work in radiation controlled areas. These workers shall adhere to applicable sections of the manual governing safety procedures and control of excessive exposure to radiation. Such work assignments may be reviewed and controlled by the RPI and/or the RSO. For the purposes of establishing radiation exposure limits, these workers will not be considered occupationally exposed radiation workers.



## 3 LICENSING REQUIREMENTS

### 3.1 UCSC License

The Radiation Safety Program at UCSC is controlled by federal and state regulations. In general, the program applies to all personnel under university auspices who use, supervise, or control radioactive materials, or use X-ray machines, accelerators, or neutron generators regardless of intensity or quantity.

Under normal circumstances, the best interests of UCSC research are served by allowing each RPI flexibility to establish and implement their own safety requirements; however, projects involving ionizing radiation have regulatory and operational requirements that require formal coordination and a degree of external control. Generally, the RPI is aware of important features of radiation control and can appreciate that in the interests of individual and public safety there must be some modification of the traditional academic freedom prevailing in the laboratory.

The RSC has accumulated a large body of experience in dealing with campus radiation problems. In view of the limited dimensions of the real and potential hazards encountered at UCSC facilities, the program of radiation control and the special health physics services represent the most satisfactory arrangements for meeting control requirements with available UCSC resources.

When requesting approval to use radiation sources, it is necessary for the applicant to understand the requirements of the state and federal regulations as they have been applied at UCSC per license conditions. In all cases, UCSC requirements must meet those specified by governmental regulations but in some cases they may be more limiting due to the special conditions prevailing upon a university campus. The applicant should know whose responsibility it is to meet these requirements and what assistance may be available to them. Copies of the state regulations, licenses and UCSC policies (this Radiation Safety Manual) are available from EH&S Radiation Safety.

The requirements most applicable to users of radioisotopes and/or other radiation sources on campus are summarized as follows:

#### 3.1.1 State Regulation of Radiation Use

The extent and form of restrictions, which apply to each user and facility, are determined by Title 17 of the California Code of Regulations (CCR). These regulations are based on the federal Nuclear Regulatory Commission regulations that govern the use of ionizing radiation in the United States as a whole. Complications sometimes arise because the regulations are intended to cover not only university research, but also industrial operations. Nevertheless, the CCR is binding for each person using sources of ionizing radiation (materials and/or machines).

#### 3.1.2 State Licensure of UCSC

Both the laboratory investigator and Department of Health Services (DHS) are aware of the difficulties inherent in providing a general set of requirements to cover the spectrum of complex situations encountered in research. Therefore, the broadest possible interpretation of these regulations has been provided to the university by means of a "Broad Scope" license for the use of radioactive materials. This license specifies possession limits for radioactive materials and other requirements for the use of these materials at UCSC. Under the terms of this license, the RSC is granted the authority to

approve a wide range of applications utilizing radiation, provided it agrees to maintain and enforce the provisions of CCR Title 17 as specified in the UCSC radioactive material license and its associated application. RSC recommendations are implemented by the RSO. **It is important that all users realize that failure to demonstrate reasonable compliance with state regulations in any campus facility could trigger state enforcement action resulting in termination of all licensed use of radiation sources at UCSC.**

### 3.1.3 Exemptions

Exemptions include consumer products containing radioactive material (e.g., balances, static eliminators, smoke detectors) listed in 17 CCR 30180(b). "Exempt Quantities" identified in 17 CCR 30180(c) which might ordinarily be acquired by an individual without a NRC or State of California license, are **NOT** exempt from the requirements of this manual.

## 3.2 Radiation Use Authorization

A Radiation Use Authorization (RUA) is required before the purchase or use of any source of ionizing radiation.

Application is made on the form appropriate to the type of authorization sought, accompanied by a written standard operating procedure and a completed training and experience form for each person working on the project. The RSO conducts a detailed health physics evaluation of the proposed project. Where additional information is required, the RSC may request the applicant to meet with them. Approval is sent in writing and will specify special conditions related to the use such as: special precautions, modes of disposal, purchase procedures, etc.

Recommendations for approval by the RSC of any proposed use of radioactive materials and/or radiation generators is based on the benefits to be received from the project, the risk/hazard evaluation, and the adequacy of health and safety measures to be employed. Factors considered by the RSC in the evaluation of safety provisions in a proposed usage include: experience and ability of the applicant and his or her assistants to cope with hazards involved in the particular application; adequacy of the facilities and equipment for proposed usage; and the thoroughness and attention given to safety precautions in the proposed experimental procedures and waste disposal methods.

A Hazard Guide Value is assigned, based on quantity per procedure, isotope toxicity, and nature of use. The RUA is then classified as Level I, II, III, or IV, depending on the highest Hazard Guide Value. Protocol for assignment of Hazard Guide Value and classification is detailed in this manual.

### 3.2.1 Application for Research Use

**For an initial application to use radioactive materials**, complete the following forms:

- ❑ *Radiation Use Authorization Application - Radioactive Materials*
- ❑ *Standard Operating Protocol – Radioactive Materials* must be completed for each experiment requiring radioactive materials
- ❑ *Statement of Training and Experience*” must be completed for each user of radioactive materials. (See sample forms in Appendix H).

**For an initial application to use machines that produce ionizing radiation**, complete the following forms:

- ❑ *Radiation Use Authorization Application - Ionizing Radiation Producing Machines*
- ❑ *Standard Operating Protocol – Radiation Producing Machines must be completed for each experiment requiring use of ionizing radiation*
- ❑ *Statement of Training and Experience must be completed for each user of the ionizing radiation producing machines.*

### 3.2.2 Application for Academic Use

A RUA is required for radiation uses in academic courses. RUAs authorizing instructional use of radioactive material for teaching or demonstration in academic courses are issued in the name of the department chair under which the class is offered. More than one class may be listed on the same RUA, but each experiment must be submitted as a separate protocol. The application for a RUA must be submitted to EH&S Radiation Safety for review and approval by the RSC (as required under Level of Review, Table 1) before the commencement of the class.

Students participating in the class will be treated as members of the public for exposure limits. Students must always work under the direct supervision of a designated user (DU) who is listed on the Instructional RUA. Only designated users listed on the RUA will be allowed to supervise the students in the use of ionizing radiation and the proper and safe work practices to prevent unnecessary radiation exposures and contamination incidents. Individuals listed on the RUA must complete all training requirements for designated users.

Listed as a separate protocol will be the course number and experiment name for each experiment that incorporates the use of ionizing radiation. The protocol will include:

1. Course number, number of instructors and designated user (DU).
2. Number of laboratory sections, number of students per section, and number of students per designated user (DU). (As the hazard potential dictates, the RSC may require that this ratio be decreased.)
3. Description of lab procedures and safety protocols, including:
  - a. Health and safety instructions for students
  - b. Radioactive waste disposal procedures for students
  - c. Extent to which students will actually be handling radioisotopes
  - d. Number and type of monitoring instruments available in the laboratory for routine use.

Each time the course is taught the following information must be provided to the RSO prior to the commencement of the class:

1. Course number and title
2. Laboratory instructor's name and designated users who will be supervising the students
3. Dates of intended use of ionizing radiation
4. Number of students anticipated
5. A list of students (including names, birth dates and social security numbers) shall immediately be given to the RSO after the class begins.

6. Radiation Safety shall be notified when the radiation work is completed so a survey may be made to verify that the radioactive waste has been disposed of properly.

#### Formal Presentation in Radiation Protection

A formal presentation in the principles and practices of radiation protection will be presented to every class. This presentation shall consist of at least 30 minutes of lecture and/or discussion, and may be presented by the instructor, the RSO, or a suitable guest lecturer. The contents of this presentation will be outlined in the RUA. This presentation must be completed before the start of work with radioactive materials in the laboratory. Failure to attend this presentation shall disqualify the student from working with radioactive materials.

#### Termination Survey

After each course finishes radioactive work, all labels, waste and other radioactive material must be removed and a termination survey must be performed. The area may then be released for general use. If the radioactive materials are to remain in the area, special arrangements need to be made with the RSO.

### **3.3 RUA Amendments**

Amendments to approved RUAs may be requested at any time by making such requests in writing or e-mail to the RSO. Any changes to, or modifications of, an existing RUA must be reviewed and approved before their implementation.

Requests for minor RUA amendments may be approved by the RSO provided the amendment does not change the RUA level, the RPI, involve changes in location providing less effective facilities for hazard control, or include the use of radionuclides of higher radiotoxicity (refer to Table 13). Examples of minor amendments are: reactivation of a discontinued project, use of a new isotope for the same procedure, possession limit increase for an existing isotope, a change of personnel working on a project, change of location, addition or deletion of rooms, or other changes which do not alter the original authorization substantially.

Requests for significant amendments may require approval of the RSC, depending on the nature and complexity in accordance with the procedures of this manual. The amendment must be approved by the RSC as prescribed in Table 1 Level of Review

### **3.4 Review of RUA Applications**

When reviewing applications for use of radioactive materials, the RSC employs the following procedure:

1. All applications are initially submitted to EH&S Radiation Safety.
2. The RSO reviews all applications for completeness and prepares them for presentation to the RSC.
3. The RSO then conducts a detailed health physics evaluation of the proposed project. This evaluation usually includes an interview with the applicant and a visit to the proposed use location(s) to evaluate the adequacy of the facilities.
  - A. Technical Proficiency and Vigilance of the Laboratory Personnel

Experience has shown that in radiation work, as in other fields, one cannot expect laboratory work habits and safety performance to improve because of the additional duress presented by potential hazards. Therefore, the proposed project is studied by the RSC to determine that all protective procedures involving radiation hazards are within the field of competency of the investigator. The RSC will, in its assessment, take into account the previous experience and special training of the personnel involved so that the proposed project does not present an unreasonable burden on the user or on EH&S Radiation Safety.

#### B. Adequacy of Facilities

Adequate facilities can minimize the potential for operational problems. Items to be considered include:

- a. Storage facilities
- b. Engineering controls (e.g., hoods, glove boxes, and other special equipment)
- c. Personal protective equipment (e.g., gloves, goggles, respirators)
- d. Housing and maintenance of experimental animals if used
- e. Impact of radiation use on surrounding areas
- f. Housekeeping
- g. Survey instruments

#### C. Familiarity with the UCSC Radiation Safety Program

Evidence will be sought to ensure that the RPI is familiar with the University Radiation Safety Program, as outlined in this manual, and that they are prepared to institute safety and management controls as required, including:

- a. Inventory records (receipts, use, transfers and disposal)
  - b. Waste disposal procedures
  - c. Monitoring methods, frequency, and records
  - d. Survey instrumentation, calibration procedures, and records
  - e. Area posting and access control
  - f. Contamination control procedures
  - g. Provision for controlling releases to the environment
  - h. Personal protective equipment
  - i. Personnel dosimetry and bioassay requirements
4. All applications are evaluated according to the requirements 17 CCR and conditions in the UCSC radioactive materials license.
  5. Approval of applications is granted by the RSO and the RSC and is sent in writing to the RPI with any additional conditions. No work may be conducted until the approval process has been completed.

### 3.5 Level of Review and Approval

Each RUA application shall be reviewed and approved by the RSC as listed in Table 1.

Any member of the RSC may request a higher level of review for any RUA. RUA Level I are normally reviewed and approved by the RSO.

RUA Level II are normally reviewed and approved by the RSO and the RSC Chairperson or designee.

**Table 1**  
**Level of Review**

RUA Level	Minimum RUA Reviewer(s)	
	Approval of Original RUA	Approval of Amendments and Renewals
I	RSO	RSO
II	RSO + 1 RSC Member	RSO
III	Quorum of RSC Members	RSO + 1 RSC Member
IV	Quorum of RSC Members	Quorum of RSC Members

RUA Level III and IV are reviewed and approved by a majority of individual RSC members or by the RSC in meeting; review techniques shall be determined by the RSC Chairperson. A negative opinion by any member of the RSC consulted requires review of the proposed Authorization by the RSC in meeting. The RSO shall be included in the reviewing body.

### 3.6 Determination of the Hazard Guide Value

All applications for radioisotope use are assigned a Hazard Guide Value (HGV). The Hazard Guide Value (HGV) is calculated by the RSO or EH&S Health Physicist for each procedure using Equation 1. This process recognizes that some experimental operations are inherently more hazardous than others by reason of the forces applied, materials used, and the chemical reactions involved. If there is uncertainty regarding intermediate steps and/or end products, the RSC may grant conditional approval to proceed with an experiment one step at a time until relevant details can be documented adequately.

$$HGV = \frac{Q \times U \times S \times C}{T} \quad \text{(Equation 1)}$$

- Q = Quantity of radioactive material used per procedure in microcuries (μCi).
- U = Use factor<sup>1</sup> from Table 2 for unsealed sources or Table 3 for sealed sources.
- S = Special hazard factors from Table 2 or 3 as appropriate.
- C = Containment factors from Table 2 or 3 as appropriate.
- T = The microcurie (μCi) quantity listed in Appendix C to 10 CFR 20.

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<sup>1</sup> The Use Factor (U) is based on the type of experimental procedures that will be involved in the proposed use of the radioisotope. Consideration is given to the probability of a) release of the radioisotope to the environment, b) contamination of persons engaged in the operation, and c) contamination of equipment and facilities.

**Table 2**  
**Modifying Factors for Operations with Unsealed Radioactive Materials**

<b>Modifying Conditions</b>	<b>Multiplication Factors</b>
<b>Use Factors (U)</b>	
Gaseous operations and complex dry operations ( <i>e.g., grinding, machining</i> ).	100
Simple dry operations ( <i>e.g., manipulation of powders</i> ), and complex wet operations ( <i>e.g., distillation, injection into humans or animals, evaporation to dryness</i> ).	10
Normal wet operations ( <i>e.g., gel separations, thin layer chromatography, centrifuging, routine chemical preparations</i> ).	1
Simple wet operations ( <i>e.g., dilution of stock solutions or adding aliquots to media</i> ).	0.1
Storage of unsealed radioactive materials.	0.01
<b>Special Hazard Factors (S)</b>	
Reactive compounds capable of generating radioactive gaseous emissions ( <i>e.g., H-3 sodium borohydride</i> ).	100
Nucleic acid precursors, nucleotides (labeled with low energy radionuclides H-3, C-14, or I-125), and skin permeable or volatile compounds ( <i>e.g., H-3 water, I-125 sodium iodide</i> ).	10
General organic and soluble inorganic compounds.	1
Insoluble inorganic compounds ( <i>e.g., microspheres</i> ), and uncompressed tritium or noble gas.	0.1
<b>Containment Factors(C)</b>	
Work on open bench or in the field or storage in a sealed container.	1
Work in standard or radioisotope fume hood or storage in a doubly sealed container.	0.1
Work in glove box or equivalent enclosed system with suitable filters or traps in exhaust ventilation or storage in a vacuum desiccator.	0.01

**Table 3**  
**Modifying Factors for Operations with Sealed (Encapsulated) Radioactive Materials**

<b>Modifying Conditions</b>	<b>Multiplication Factors</b>
<b>Use Factors (U)</b>	
Experimental procedures with sealed sources.	0.1
Storage of sealed sources in unshielded area.	0.01
Operation of irradiator with internal chamber, and storage of sealed sources in shielded area.	0.001
<b>Special Hazard Factors (S)</b>	
The Special Hazard Factor for a gamma and/or neutron emitter will be the dose rate in millirems per hour at 30 centimeters from a 1mCi point source.	
The Special Hazard Factor for a beta emitter, with beta radiation capable of penetrating through the source or covering over the radioactive material, will be set at $10 \times E$ , where E is the total beta energy per disintegration (in MeV). For beta emitters that also emit gamma and/or neutron radiation, the special hazard factor will be the sum of the individual special hazard factors for the different types of radiation.	
<b>Containment Factors(C)</b>	
Single encapsulation with mylar or plastic covering.	0.1
Single encapsulation in strong metal containers, or double encapsulation in strong metal containers, with one or both containers not welded closed under an inert gas atmosphere.	0.01
Double encapsulation in strong metal containers, with both containers welded closed under an inert gas atmosphere.	0.001

### 3.7 RUA Level

The RUA Level assigned to an authorization is based on the individual procedure with the highest HGV as listed in Table 4.

**Table 4**  
**RUA Levels**

<b>RUA Level</b>	<b>Maximum Individual Procedure HGV</b>	<b>Radiation Producing Machines</b>
I	$\leq 1$	Cabinet, XRF
II	$\leq 100$	XRD, Medical
III	$\leq 10,000$	Other so designated <sup>2</sup>
IV	$> 10,000$	

### 3.8 Classification of Workplaces<sup>3</sup>

Requirements for facilities and containment equipment are based on the HGV calculated for the specific procedure being considered. Operations which involve potential airborne hazards may require special consideration.

**Table 5**  
**Laboratory Classification**

<b>Laboratory Classification</b>	<b>HGV</b>
Type C	$\leq 100$
Type B	$\leq 10,000$
Type A	$> 10,000$

#### 3.8.1 Type C “Normal” Laboratories

Type C laboratories are campus laboratories with impervious bench tops and floors which meet standard chemical laboratory requirements concerning items such as dilution ventilation, fume hood design, earthquake safety, emergency showers, emergency exits, fire extinguishers and security.

<sup>2</sup> Radiation producing machines so designated by the RSO with the agreement and approval of the RSC.

<sup>3</sup> The classification of radioisotope use laboratories is based upon recommendations from the International Labor Office Guidelines for the Radiation Protection of Workers in Industry (Ionizing Radiations) Occupational Safety and Health Series 62, 1989

1. Radioactive materials must be stored in suitable refrigerators, freezers, or receptacles approved by the RSO.
2. Gloves and adequate protective clothing must be worn.
3. Absorbent paper must be used on work surfaces and appropriate waste disposal containers must be available.
4. If volatile materials are used, work must be conducted in a fume hood.
5. The design, construction and equipment of a Type C workplace should be similar to those of a good quality modern chemical laboratory.
6. Normal ventilation is usually sufficient, and could be complemented with continuous movement of air into a fume hood.

### 3.8.2 Type B “Radioisotope” Laboratories<sup>4</sup>

A Type B workplace should be specially designed, constructed and equipped for work with radioisotopes. In addition to the design requirements of a Type C laboratory, the RSC may require Type B laboratories to have some or all of the following:

1. Impervious floors with one-piece construction and covered corners to facilitate decontamination.
2. Restricted access to, and use of, the area. All work must involve radioactive materials, and no desk space or “dual” use of the area permitted.
3. The workplace should have reduced air pressure relative to the surrounding areas. Special attention should be given to avoiding the recirculation of air and the dispersion of contamination to other occupied areas.
4. HEPA filters and/or other suitable filters or traps in the exhaust ventilation. There should be a space for an absolute filter to be put between the fume hood and the ventilation duct allowing for easy change of the filter and for monitoring the negative pressure gradient.
5. The levels of airborne activity should be kept as low as reasonably achievable by the use of fume hoods or glove boxes of appropriate design and construction. The speed of the air flow should be regular, without eddies, and should be such that there can be no escape of air from the fume hood into the workplace under typical operating conditions, including the opening of windows and doors and the suction of other fume hoods.
6. The surfaces of the hood and the ventilation system should be smooth and made of non-absorbent material that can withstand the chemicals normally used in the hood. The gas, water and electrical outputs should be operated from outside the hood.
7. Where appropriate, continuous external radiation, general room air and/or exhaust duct monitoring systems with alarms.
8. Automatic fire suppression equipment.

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<sup>4</sup> Adapted from the American Standards Association, Inc. *Design Guide for a Radioisotope Laboratory (Type B)*.

9. Additional administrative controls as approved by the RSC, such as protective clothing (e.g. shoe covers, one-piece coveralls, etc.), more frequent monitoring, air sampling, and exit or portal contamination monitors.
10. A properly labeled waste container with lid should be available for the collection of low activity waste.
11. Facilities for washing hands should be foot or elbow operated.
12. A special room or area should be provided for storing radioactive substances.

### 3.8.3 Type A “High Activity” Laboratories

A type A workplace should be specifically designed, constructed and equipped for handling large quantities of radioactive material in accordance with the specifications and requirements set by the RSC. Type A laboratories require some or all of the following additional design features in addition to the requirements of a Type B laboratory:

1. Sophisticated access control provisions including security systems with alarms.
2. Clothing change area with lockers and showers.
3. Remote handling equipment such as caves or shielded hot cells with manipulators or robot arms.
4. Glove boxes with additional HEPA filters and/or other suitable filters or trap series with filtration in the general exhaust ventilation.
5. Processes involving risks of air contamination should be carried out in completely enclosed glove boxes or hot cells under negative pressure and provided with filters and transfer boxes.
6. Radioactive substances should be stored only in a special room equipped with suitable shielding and ventilation, and in accordance with the provisions as regards waste storage.
7. High level, shielded, waste collection facilities.
8. Additional radiation safety features and administrative controls as may be required by the RSC.

### 3.9 Radiation Use Authorization Renewal

Each year EH&S Radiation Safety will send a form called the "*Radiation Use Authorization Update Report*" to each RPI. The purpose of this form is to determine the status of the projects under a particular designated user. If a project is to continue, the RPI must provide all relevant information specified on the status report and no further reapplication is required. If a project has been completed, a closeout survey will be conducted and the RPI's name will be removed from the list of active designated users. Annual renewals involving no increase in RUA level will be approved as indicated in Table 1.

### 3.10 Registration of Machines

All machines that produce ionizing radiation must be registered with the State of California. This activity is coordinated through EH&S Radiation Safety.

### 3.11 EH&S Radiation Safety Audits

The frequency of routine radiation safety audits conducted by EH&S Radiation Safety is based on the RUA Level as indicated by Table 6, or as determined necessary by the RSC and/or by the RSO.

**Table 6**  
**EH&S Radiation Safety Audit Schedule**

RUA Level	Health Physics Survey Schedule	
	Subcategory A	Subcategory B
I	Semi-annual	Annual
II	Quarterly	Semi-annual
III	Monthly	Quarterly
IV	Weekly	Monthly

Subcategory A is assigned to all RUAs. At the discretion of the RSO, continuing RUAs maybe audited according to Subcategory B.

EH&S Radiation Safety audits are intended to determine if operations are being conducted properly and safely. Specific items checked include:

- Verification that required records are maintained and current.
- Whether lab procedures are available and followed.
- Posting of areas and materials and safety notifications.
- Confirmation that radioisotopes are used in accordance with the conditions of the RUA and RSM.
- A contamination/area survey as appropriate.

In the event that contamination and/or external radiation areas are found, or if other problems are identified, it will be the duty of the RPI to take corrective action.

A report of the audit will be kept on file in EH&S Radiation Safety and a copy sent to the RPI.

#### 3.11.1 Noncompliance

In the event that items in noncompliance are identified, a report will be issued by EH&S Radiation Safety detailing the non-compliant item(s) in need of correction and the action required. A timetable will be established with a deadline for making corrections. The report is to be reviewed by the principal investigator, signed and placed with the radiation safety records for the laboratory.

If the noted problems are corrected, no further actions will be required. If the problems are not corrected and are cited on the next inspection, a sanction as indicated by Table 7 below will be enacted.

Violations are classified into four severity levels, Administrative, Low, Medium and High. If violations are found, actions that may be taken are geared to these severity levels. The severity levels for violations are derived from NRC regulations and from UCSC's recent safety history.

Chronic noncompliance could result in an administrative review by the RSC and may lead to cancellation of the RUA. Where evaluation by the RSO indicates recurring or chronic problems, continued authorization of the RUA by the RSC may be contingent upon a more extensive monitoring program and additional personnel training.

**Table 7**  
**Sanctions for Repeat Noncompliance**

<b>Severity Level</b>	<b>1<sup>st</sup> Offense</b>	<b>2<sup>nd</sup> Offense</b>	<b>3<sup>rd</sup> Offense</b>
High	Warning letter accompanies the inspection report indicating that a repeat of the violation will trigger a sanction.  Lab Audit Schedule set to Subcategory A. <sup>5</sup>	One-week temporary suspension of the RUA. Issue addressed at the RSC's next meeting. RPI will have to appear before the RSC.	Permanent suspension of work until the RSC reauthorizes the RUA.
Medium	Standard inspection report issued.	Warning letter accompanies the inspection report indicating that a repeat of the violation will trigger a sanction.  Lab Audit Schedule set to Subcategory A. <sup>5</sup>	One-week temporary suspension of the RUA. Issue addressed at the RSC's next meeting. RPI will have to appear before the RSC.
Low and Administrative	Standard inspection report issued.	Warning letter accompanies the inspection report indicating that a repeat of the violation will trigger a sanction.	Issue addressed at the Committee's next meeting. RPI will have to appear before the RSC.  Lab Audit Schedule set to Subcategory A. <sup>5</sup>

In the event of any single serious violation or discovery of unsafe conditions, the RSO shall bring this matter to the attention of the RPI. If no corrective action is taken, the RSO has the authority to impose cessation of the operation and/or to confiscate radioactive materials. The RSO shall promptly report all serious instances of non-compliance to the RSC chairperson.

### 3.12 Termination Procedures for Authorizations

In the event that any RPI (or person working under the supervision of the RPI) is found to be willfully and/or negligently violating any of the federal, state, or university regulations governing the use of radioactive materials and/or radiation producing machines, any or all RUAs under that RPI may be suspended or revoked by the RSO, with the concurrence of the RSC, and any radioactive materials in his/her possession may be impounded.

<sup>5</sup> Refer to Table 6 -EH&S Radiation Safety Audit Schedule

An RUA will ordinarily be terminated by EH&S Radiation Safety upon notification that a project has been completed and that no sources of radiation are to be retained by designated users.

Upon termination of the RUA, an accounting of all radioisotopes or radiation producing machines acquired thereunder must be reported to the RSO. All remaining radioactive materials must be transferred to another active RUA that is authorized for the radionuclides and their quantities or to EH&S Radiation Safety for disposal.

EH&S Radiation Safety shall be notified of the termination of projects using radioisotopes in sufficient time to permit scheduling of the final monitoring of radiation use areas, accounting of radioisotope inventory, and satisfaction of requirements for personnel monitoring.

### **3.12.1 Decommissioning Of Facilities And Equipment**

Once radioactive materials or radiation producing machines are used in an area, there is the possibility of contamination and/or activation of surfaces and equipment. Before such areas and equipment can be released for unrestricted use they must be surveyed by EH&S Radiation Safety and, if necessary, decontaminated to the levels specified in Section 6.11 of this manual. Decontamination is the responsibility of the RPI, but EH&S Radiation Safety will provide technical assistance and supervision if necessary.

### **3.13 Physical Examination Requirements**

The RSO has the authority to require that the user of any source of radiation submit to physical or medical examination, including bioassay and medical monitoring, that the RSC may deem necessary or required by regulations to ensure safe operating procedures and protection of health. Bioassay and medical monitoring procedures are found in Part 4 of this manual. If the RSO at any time is not satisfied with the adequacy of safety and health practices employed in a project, the RSO may require cessation of the project until satisfactory procedures have been adopted. Appeal of such an action may be made at the next scheduled meeting or at a special session of the RSC.

### **3.14 Summary**

The requirements summarized above establish a minimum level for radiation control. These requirements are related to regulatory conditions that deal primarily with personnel and environmental exposure or contamination in a general setting. Since the educational and research environment has special scientific and technical needs, it is often advisable to address these additional requirements. Specific areas to consider include the contamination of low-level counting equipment and the unnecessary exposure of personnel and students.

## 4 RADIATION EXPOSURE POLICY

### 4.1 ALARA Policy

UCSC has an aggressive policy to prevent unnecessary radiation exposures to persons and the environment and to reduce all exposures to as low as reasonably achievable (ALARA), in accordance with the recommendation of the National Council on Radiation Protection and Measurements (NCRP), and all federal and state regulatory requirements.

### 4.2 Occupation Dose

Radiation exposure shall be "As Low As Reasonably Achievable" (ALARA), but in no case exceed the dose limits specified below when exposures from external and internal sources are added together:

**Table 8**  
**Occupational Dose Limits**

<b>Category of Dose Equivalent</b>	<b>Regulatory NRC Limit<sup>6</sup></b>	<b>UCSC Administrative Guideline<sup>7</sup></b>
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 (individuals <18 years of age):	10% of NRC limit allowed for adult workers	20% of UCSC administrative guideline allowed for adult workers

No RPI shall possess, use, or transfer sources of ionizing radiation in such a manner as to cause any individual in a controlled or restricted area to receive an occupational dose in excess of the NRC limits established in Table 8. All activities conducted in a controlled area shall limit the exposure of non-radiation users to the regulatory limits for members of the public (refer to Table 9).

<sup>6</sup> Regulatory limits are legal dose equivalent limits in effect that have been adopted by the NRC and/or DHS.

<sup>7</sup> Administrative guidelines are dose equivalent recommendations for all UCSC personnel which have been adopted by the RSC. These guidelines should not be exceeded in routine operations without prior RSC approval. The administrative guidelines are not intended to be absolute limits, but are established in order to provide guidelines for keeping exposures ALARA.

**Table 9**  
**Public Dose Limits**

<b>Category of Dose Equivalent</b>	<b>Regulatory NRC Limit</b>	<b>UCSC Administrative Guideline</b>
Annual Limit:	100 mrem/yr	10 mrem/yr
Exposure in any one hour:	2 mrem/hr	0.2 mrem/hr

Public exposure limits apply to students involved in educational activities, “non-occupational” exposed staff and members of the public.

### 4.3 Prenatal Radiation Exposure Policy

#### 4.3.1 Federal and State Regulations

Federal and state dose limits and monitoring requirements for declared pregnant workers are as follows:

1. The dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 500 millirems (5 mSv), delivered at a recommended rate of approximately 50 millirems per month or less.
2. A declared pregnant woman is required to be monitored for doses from external exposure if she is likely to receive, while she is pregnant, a deep-dose equivalent (DDE) of greater than 50 millirems per year.
3. A declared pregnant woman is required to be monitored for doses from internal exposure if she is likely to receive, while she is pregnant:
  - a. A committed effective dose equivalent (CEDE) of greater than 50 millirems per year, or,
  - b. A dose to the embryo/fetus of greater than 50 millirems per year from radionuclides in the embryo/fetus and in the declared pregnant woman.
4. If a pregnant woman chooses not to become a declared pregnant woman, the appropriate dose limits and monitoring procedures apply based on her status as an adult or minor.

**Table 10**  
**Declared Pregnant Woman Dose Limits**

<b>Category of Dose Equivalent</b>	<b>Regulatory NRC Limit</b>	<b>UCSC Administrative Guideline</b>
Gestational Period:	500 mrem	500 mrem
Total per Month	50 mrem/month	50 mrem/month

### 4.3.2 Exposure of Pregnant Women

Federal and state regulatory agencies have established the category of declared pregnant woman in order to address two competing objectives of national policy. These objectives are:

1. The desire to establish a legal mechanism to offer special protection to the developing embryo/fetus by limiting external and internal doses to levels lower than those established for the mother.
2. The U.S. Supreme Court Decision that prohibits the establishment of mandatory legal dose limits for women that are lower than the legal dose limits for men.

Therefore, each woman must choose to become a declared pregnant woman if she wants to have voluntary lower legal dose limits for the exposure of her developing embryo/fetus.

UCSC procedures establish administrative criteria for external and internal dosimetry for declared pregnant women that are often lower (e.g., for penetrating gamma radiation emitters and most internal exposures) than those established for adults who are not declared pregnant women.

### 4.3.3 Specific Information for Prospective Mothers

It is UCSC's policy to inform female radiation workers (employees and students) of:

1. The risks to the developing embryo/fetus from exposures to ionizing radiation.
2. The options available to prospective mothers to maintain such exposures as low as reasonably achievable below the in utero legal limit of 500 millirems (for declared pregnant women) during pregnancy for external and internal exposures.

All female radiation workers are strongly encouraged to contact the EH&S Office if they have any questions regarding radiation exposures during pregnancy.

### 4.3.4 Special Precautions for Prospective Mothers

Precautions required or recommended for prospective mothers (i.e., those who are pregnant or who are actively trying to become pregnant) who choose to continue working with or around radioactive materials and/or radiation-producing equipment, include:

1. The prospective mother should avoid situations where her abdomen may be exposed to penetrating radiation (gamma, X-ray, neutron) levels greater than 2 millirems per hour or 10 millirems per week.
2. Protective aprons may be worn, if appropriate for the energy and type of radiation encountered. Thin lead aprons may be used for X-rays, but they are not recommended for use with gamma emitters (such as Cr-51) or high energy beta emitters (such as P-32).
3. The EH&S Office may issue a radiation dosimeter to a declared pregnant woman to be used as a "fetal monitor" to assess penetrating radiation exposures (from external sources) to the prospective mother's abdomen whenever it is likely to receive a deep dose equivalent of more than 50 millirems in a year and the woman's usual dosimeter is likely to measure doses that are less than the doses to the abdomen.

4. If the deep dose equivalent to the embryo/fetus of a declared pregnant woman equals or exceeds 50 millirems per month for more than two consecutive months of a pregnancy, the prospective mother's work will usually be reviewed to determine if restrictions are necessary to reduce further exposures during the remainder of the pregnancy.
5. If the dose equivalent to the embryo/fetus of a declared pregnant woman exceeds 500 millirems during her pregnancy, the woman will normally be required to avoid all further occupational and educational radiation exposure until after the birth of her baby.
6. The prospective mother should avoid working with volatile or reactive radiochemicals that could result in the inhalation, ingestion, or absorption of radioactive materials through her skin.
  - a. While pregnant, she should not perform either iodinations using radioiodine or labeling procedures using tritiated water or borohydride.
  - b. Nursing mothers should also avoid such procedures.
7. In any case of suspected accidental exposure to radiation sources or uptake of radioactive materials, the prospective mother should contact the EH&S Office immediately, or call campus police after hours, or on weekends or holidays.

#### 4.4 Personnel Monitoring

In recent years, many research procedures and other uses of radiation have been refined such that exposures are often reduced to the point that personnel monitoring is not needed. The following defines those conditions that require monitoring.

##### 4.4.1 Requirements

Personnel monitoring is required, per 10 CFR 20.1502, for adults, minors or declared pregnant women likely to receive doses from external sources in excess of ten percent (10%) of their respective NRC limits, or by individuals entering a high radiation or very high radiation area. Personnel monitoring devices are devices worn or carried by an individual for the purpose of measuring the dose received. Examples include pocket dosimeters, film or thermoluminescent dosimeters (TLD), or electronic exposure rate dosimeters.

Dosimeters should be stored away from excessive heat and in a "background" radiation area when not being used.

- a) **Whole body monitoring** of external radiation exposure is usually by TLD badges that are changed quarterly. The RSO may designate shorter wear periods if needed. The new badges are sent to the RPI for all designated users. Dosimeters are provided to those who choose to be monitored, but who would not otherwise be required to do so.
- b) **Extremity monitoring** is provided, in addition to whole body monitors, when the extremity exposure is likely to be greater than 10 times the whole body exposure. Extremity monitors are usually TLD rings that are changed quarterly.

#### 4.4.2 Supplementary Dosimetry Dosimeters

If the type of radiation is such that their readings will be meaningful, pocket dosimeters will be worn:

- a) Whenever a person attempts a new procedure where the expected radiation exposure is not known.
- b) Whenever a person engages in a procedure involving radiation exposure levels that could potentially cause an over-exposure.

Except for visitors, any person wearing a pocket dosimeter must also wear a film or TLD badge. If use of a pocket dosimeter is required as a condition of the approval, its reading must be recorded in the "laboratory journal" along with the date of the readings and the specific use of the dosimeter.

#### 4.4.3 Proper Use of Personnel Monitors

1. Wear personnel monitors at all times when working with radiation.
2. Wear monitors properly:

**Whole body monitors** can be worn on the belt or at chest level but if a leaded apron is worn, the monitor must be worn at the collar outside of the apron.

**Extremity Monitors** are usually worn on a finger with the detector on the palm side of the finger.

3. Store monitors away from sources of radiation when not in use.
4. Avoid exposing the monitor to environmental extremes (e.g., moisture or heat).
5. Exchange monitors promptly when the replacements arrive.
6. Use only a monitor that is issued to you.

#### 4.5 Bioassays

Individuals are monitored for internal exposure by means of bioassay, which is the analysis of the uptake of radioactive materials in the body by direct counting of the body or body parts (*in vivo*), or by the analysis of excreta (*in vitro*). There are two types of routine bioassays at UCSC, thyroid counts for radioiodine and, very infrequently, urine assays for tritium.

Measurements of uptake in bioassays must be converted to the estimated total intake in order to calculate the CEDE to the individual and CDEs to the organs and tissues of the individual. The intake of radioactive materials occurs in the year of dose calculation, but the actual doses can be received over greater periods of time (up to 50 years for very long half-life radionuclides).

##### 4.5.1 Federal and State Regulatory Requirements

Federal and state regulations require individual monitoring for any person who has the potential for intake of radioactive materials under such conditions that they are likely to receive internal doses exceeding ten percent of any of the applicable regulatory limits.

There are few, if any, individuals at UCSC who are required to have bioassays under the provisions of NRC and/or DHS regulations. However, for campus administrative purposes:

1. The UCSC radioactive materials license requires bioassays for individuals using large quantities of radioiodine and/or tritium.
2. Campus administrative procedures may establish lower quantities of radioisotope utilization for bioassays to be required or recommended.

#### 4.5.2 Participation

All workers handling radioactive iodine in amounts exceeding those in Table 11 and other workers within a few meters and in the same room where the process is carried out shall be monitored. Routine bioassay will be required for all individuals who exceed the limits indicated in Tables 11 and 12.

Specific procedures and requirements for bioassay can be obtained from EH&S Radiation Safety.

**Table 11**  
**Activity Levels Above Which Bioassay for I-125 or I-131 is Necessary<sup>8</sup>**

Types of Operation	Activity Handled per Calendar Quarter <sup>9</sup> in Unsealed Form	
	Volatile or Dispersible	Bound to Non-volatile Agent (or RIA Kits)
Processes in open room or bench, with possible escape of iodine from process vessels	0.1 mCi	1 mCi
Processes with possible escape of iodine carried out within a fume hood of adequate design, face velocity and performance reliability	1 mCi	10 mCi
Processes carried out within glove boxes, ordinarily closed, but with possible release of iodine from process and occasional exposure to contaminated box and box leakage	10 mCi	100 mCi

<sup>8</sup> From USNRC Regulatory Guide 8.20, as amended by 10 CFR 20

<sup>9</sup> Cumulative, or on one or more occasions in that period

**Table 12**  
**Activity Levels Above Which Bioassay for H-3 is Necessary<sup>10</sup>**

Types of Operation	Activity Handled at Any One Time	
	HTO <sup>11</sup> or Other Tritiated Compounds (including Nucleotide precursors)	Tritium (HT or T <sup>2</sup> ) <sup>12</sup> Gas in Sealed Process Vessels <sup>13</sup>
Processes in open room or bench with possible escape of tritium from the process vessels	0.1 Ci	1 Ci
Processes with escape of tritium carried out in a fume hood	1 Ci	10 Ci
Processes carried out within glove boxes that are ordinarily closed but with possible release of tritium from process vessels and occasional exposure to contaminated box and box leakage	10 Ci	100 Ci

#### 4.6 ALARA Review of Exposures

All exposure results will be reviewed by EH&S Radiation Safety. Exposures  $\geq$  100 mrem on a whole body badge, or 500 mrem on an extremity badge, will be investigated by EH&S Radiation Safety to determine the cause and to identify how future exposures can be reduced.

##### 4.6.1 Routine ALARA Exposure Investigations

Combined external and internal radiation exposures are routinely investigated by an EH&S health physicist to determine the conditions of exposure and to suggest preventive measures to maintain future exposures ALARA if they reach 20 percent of any applicable UCSC Administrative Guideline during the year.

A lower monthly exposure may be investigated for any reason. The RSC may authorize higher investigation levels for individuals or groups of individuals, as appropriate.

##### 4.6.2 Special ALARA Exposure Investigations

The RSO will conduct a special ALARA exposure investigation, which will be reviewed by the RSC, when any individual's combined external and internal exposures reach 50 percent of any applicable UCSC Administrative Guideline during the year.

<sup>10</sup> From USNRC Regulatory Guide 8.32, as amended by 10 CFR 20

<sup>11</sup> HTO is a symbol for a water molecule in which a tritium atom (T) is present in place of a normal hydrogen atom (H).

<sup>12</sup> A molecule of hydrogen gas contains two hydrogen atoms. Either one of these atoms may be replaced with T to form HT, or two T atoms may combine to form T<sub>2</sub> gas.

<sup>13</sup> This assumes that adequate air monitoring has established that there is no tritium leakage or that no significant amount of tritium gas can be converted to HTO before intake.

#### **4.6.3 Investigation of Over Exposures**

EH&S Radiation Safety is responsible for notification of DHS in cases of known or suspected exposure above the regulatory dose equivalent limits.

Medical evaluation and/or treatment by a qualified physician for any overexposed personnel may be required by the RSO, the RSC, or the appropriate regulatory agency.

Whenever the UCSC Administrative Guidelines have been reached or exceeded, personnel will usually be required to avoid work with radioisotopes and/or radiation-producing machines for the remainder of the year.

#### **4.7 Distribution of Monitoring Results and Notifications**

Exposures measured by personnel monitors and determined from bioassays are reviewed by the RSO. An annual summary will be distributed to every person receiving dosimetry. The worker can request in writing a summary report of exposures received while working at UCSC at any time.

## 5 REGISTRATION AND TRAINING OF PERSONNEL

All radiation workers engaged in the use of radioactive materials under the supervision of an RPI must be registered with EH&S Radiation Safety and be specifically named on the RUA. Each proposed radiation worker must submit a *Statement of Training and Experience* to the RSO. The RSO, after review, may restrict the activities of such personnel if training and experience are found inadequate. Approved personnel are designated as radiation workers and recorded as designated on each RUA.

Radiation workers who are occupationally exposed must be informed of the hazards that they may encounter and of methods available to protect themselves.

To satisfy the training requirements, the RSC requires that:

1. All of those working with ionizing radiation be trained to use it safely prior to the start of work with radiation.
2. DUs complete refresher training at least annually and otherwise take every opportunity to improve their technical and professional proficiency, with regards to safety.
3. EH&S Radiation Safety provides general and, upon request, specialized training to meet most training requirements. When necessary, additional training from outside sources may be recommended.

### 5.1 Training in Radiation Safety

The RSC shall be responsible for specifying an ongoing training program for the handling and safe use of radioisotopes and other hazardous radiation sources. The training program shall include formal training for new users and at least annual retraining of all other users. Training sessions shall be given at periodic intervals. Proposed radiation workers, radiation workers, and in some cases RPIs, may be required to attend training sessions.

It shall be the joint responsibility of the RSO and the RPI to ensure that each radiation worker under his/her direction is properly trained in radiation safety.

### 5.2 RPI's Safety Training Responsibilities

The RPI shall be responsible for informing and instructing all individuals working in or frequenting any portion of a controlled area. They shall be:

1. Kept informed of the storage, transfer or use of radioactive materials or radiation level in any portion of a controlled area.
2. Instructed in certain aspects of safety training as specified by the RSO or as described in the RUA conditions.
3. Instructed to observe the applicable provisions of the manual for the protection of personnel from unnecessary exposure to radiation or radioactive materials.
4. Instructed to report promptly to the RPI any condition that may lead to or cause a violation of the manual's requirements for preventing excessive exposure to radiation or to radioactive materials.
5. Instructed in the appropriate responses to warnings made in the event of any unusual occurrence or machine malfunction that may result in excessive exposure to radiation or to radioactive material.

6. Expected to read the Radiation Safety Manual, to know of its location in the laboratory, and to read all required postings.

## 6 LABORATORY STANDARD OPERATING PROCEDURES

Every person who uses radioactive materials or radiation producing equipment is responsible for handling materials in such a manner as to ensure that personnel radiation exposures are ALARA. This section includes standard laboratory procedures and requirements to accomplish this. The RUA will usually prescribe additional specific precautions and conditions.

### 6.1 Procurement Procedures

Prior approval for the procurement of all radioactive materials and radiation producing equipment is required whether procurement is by a purchase, transfer, loan, or gift. The criteria for approval are based on the RPI possessing a valid RUA.

#### 6.1.1 Submission of Requisitions

Requisitions for radioisotopes or radiation producing machines are submitted to the Purchasing Department. Specific information provided on the form shall include the following information where applicable, plus other information required by the Purchasing Department:

1. Name of radioisotope in standard nomenclature, e.g., H-3 or I-125.
2. Quantity of isotope in curies or submultiples.
3. Chemical and physical form of the radioisotope.
4. Manufacturer of each radioisotope or radiation producing machine.
5. Maximum tube voltage and current for each radiation producing machine.
6. Identification number of the approved Radiation Use Authorization (RUA).

#### 6.1.2 Approval of Requisition

On receipt of a requisition, the Purchasing Department will refer to the RUA as supplied by EH&S Radiation Safety to ensure:

1. Validity of the RUA.
2. Conformity of radioisotopes requisitioned with the radioisotope and chemical or physical form authorized.
3. Limits set in the RUA on the quantity that can be acquired.

#### 6.1.3 Approval and Recording of Transfers

Before any transfer of radioactive materials between RPIs, written or verbal approval from the RSO or his/her delegate must be obtained. Both the transferor and recipient must record the applicable changes in their radioactive materials inventory.

Off-campus transfers are governed by federal and state regulations; therefore, all arrangements for such transfers shall be made by EH&S Radiation Safety.

### 6.2 Receipt of Radioactive Material

All radioisotope shipments are delivered by the carrier to the Natural Science Receiving Department for pickup and inspection by EH&S Radiation Safety. Radiation Safety inspects all packages with respect to the following:

1. Conformity of radioisotopes with the approved requisition specifications.
2. Damage or contamination of the contents or shipping containers.
3. Conformity with D.O.T. regulations.

If the radioisotope shipment passes inspection, it is delivered to the RPI's laboratory and the amount of material received is added to EH&S Radiation Safety records of radioisotope receipts. Approval must be obtained in advance for special handling of shipments that do not follow the procedures described above.

### **6.3 Security of Radioactive Material**

The RPI shall be continuously responsible for the custody of any radioactive material or radiation producing machines acquired under the RUA.

Any loss of radioactive material must be reported to EH&S Radiation Safety (x9-2553) as soon as possible after the loss is noted.

#### **6.3.1 Restricted Area**

A Restricted Area is one of high security into which access is restricted to authorized personnel in order to prevent undue risk from exposure to radiation or radioactive materials. All entrances to restricted areas shall 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 EH&S Radiation Safety staff.

#### **6.3.2 Controlled Area**

A Controlled Area is a limited access area in which licensed radioactive materials are used or stored in amounts greater than or equal to ten times the activities for the radionuclides from Appendix G (as per Equation 2) or an area where doses to visitors may exceed 10 millirem in one year or 0.2 millirem in one hour. Requirements for a controlled area include:

1. Restricting access (i.e. door locks or locked storage) to the area when it is not occupied by authorized personnel.
2. Identifying, with signs, the area(s) exposed by radiation and/or the area where radiation sources are used or stored.
3. Licensed radioactive materials stored or used in controlled areas shall remain either under the surveillance of authorized personnel or else secured from unauthorized removal or access.

### **6.4 Controlled "Radiation Use" Areas**

Where radioactive materials are stored or used in quantities greater than 10 times the quantities listed in Appendix G (as per Equation 2), the area shall be treated as a "controlled area."

### **6.5 Inventory Control and Possession Limit**

Each RPI shall keep records of physical inventories of all radioactive materials under their control. This inventory shall be by isotope, millicurie amount, activity date and storage location. For unsealed sources the inventory records should also include sufficient additional information

to facilitate locating the materials such as: how much activity is stored in the original container; how much has been transferred to another container (in solution, for example); how much is stored in tissue; how much is in liquid or solid waste, etc. Someone in each lab should be responsible for periodically verifying visually the locations of all materials inventoried. The RPI is responsible for ensuring that the records are kept current and accurate.

Care must be taken to ensure that the user does not exceed the possession limit(s) (by isotope and chemical form) specified in the authorization. In order to ensure this, the following requirements are established:

1. Each order must be within the specified limits listed on the RUA.
2. The Quarterly Inventory Verification form sent to each user by EH&S Radiation Safety must be completed and returned promptly.
3. Although each order is checked by EH&S Radiation Safety, the user must be aware of his/her possession limit, so as not to place multiple orders that would exceed it.

## 6.6 Posting Requirements for Radiation Laboratories

Radiation warning signs of the approved type are required where the potential for exposure to radiation exists.

All laboratory areas must post:

1. The "Notice to Employees" Form (RH-2364) sign. This is a form that outlines specific rights to fair and safe treatment for radiation workers, and must be posted at appropriate locations as required by 17 CCR §30255.
2. Standard laboratory procedures.
3. Emergency laboratory procedures and phone numbers.

### 6.6.1 Caution Radioactive Material

Laboratories that store or use radioisotopes in quantities greater than 10 times the limits stated in Appendix G must be posted at all entrances with a sign bearing the radiation caution symbol and the words "CAUTION-RADIOACTIVE MATERIAL(S)." If several isotopes are present, the access doors must be posted when the sum of the ratios of the activities present to the activities from Appendix G is greater than 10.

Where:

$$\sum_i \frac{A_i}{A_{ii}} \geq 10 \quad \text{(Equation 2)}$$

$A_i$  = Activity Present

$A_{ii}$  = Activity from Appendix G

### 6.6.2 Caution Radiation Area

This sign is specifically designated for and shall be posted in any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

## **6.7 Labeling Requirements**

### **6.7.1 Containers**

Each vial or container, except those containing counting samples (planchets and vials), must bear a label with the required information. Where double containers are used, both inner and outer containers require labeling unless the inner label is visible from outside. Proper labeling requirements also apply to radioactive waste.

Labeling is not complete unless this information is entered on the label. All containers and sealed sources of radioactive materials should be labeled with:

1. Radiation Trifoil with text "Caution: Radioactive Material"
2. Isotope
3. Quantity
4. Date

Containers being used in the laboratory with less than the activities listed in Appendix G and with a designated user constantly present need not be labeled.

### **6.7.2 Equipment**

The labeling requirements will depend on the relative permanency of the radiation operation. Any apparatus that will contain greater than twice background amounts of radioactivity for eight hours or overnight either due to prolonged experimentation or due to contamination must be labeled.

### **6.7.3 Work Areas**

In addition, all work areas, including tabletops and equipment, used in radioisotope procedures must be labeled. A good method to use is to cover bench tops in work areas with absorbent paper and use "Radioactive Material" tape to secure edges to the desk. Storage areas such as refrigerators must be properly labeled.

### **6.7.4 Sealed Sources**

The source, its shield, or the apparatus in which the source is mounted must bear a permanent radiation warning sign. Even though such sources are fully and effectively controlled, all persons associated with their operations are to be informed regarding both operational and emergency precautions.

## **6.8 Radiation Exposure and Contamination Control in the Laboratory**

The level of radiation control is based in part on the RUA level assigned to the project. The RUA Level reflects consideration of the internal radiotoxicity (related to the maximum permissible body burden), the external radiation exposure hazard, the complexity of procedures, the physical and chemical characteristics of the material used, etc. As a guide, Table 13 ranks selected isotopes according to radiotoxicity.

**Table 13**  
**Classification of Isotopes According to Relative Radiotoxicity Per Unit of Activity<sup>14</sup>**

Relative Radiotoxicity	Appendix C Quantity (μCi)	Selected Radioisotopes
5 – Very High	0.001	Ac-227, U-233, U-235, Np-237, Pu-239, Am-241, Cf-252
	0.01	*Pb-210
	0.1	Sr-90, Po-210, Ra-226,
4 – High	1	Si-32, *Co-60, Ru-106, Cd-109, *I-125, *I-131, Rn-222
3 – Moderate	10	*Na-22, P-32, Cl-36, *Fe-59, *Zn-65, Cs-134, Cs-137, Pm-147, *Th-234,
2 – Low	100	C-14, P-33, S-35, Ca-45, Mn-54, Fe-55, *Co-57, Ni-63, Se-75, *Rb-86, Ba-133, Tl-204, Th-232, U-238,
1 – Slight	1000	H-3, *Cr-51, Tc-99m

\*Emit gamma or X-rays in significant amounts

### 6.8.1 Internal Contamination

Risks that can result from internally deposited radionuclides are a matter of personal and public concern. Internal uptake is best avoided by implementing containment techniques, minimizing surface contamination, using appropriate personal protective equipment, and using proper engineering controls.

The following precautions are to be taken when working with unsealed radioactive materials in order to prevent the intake of these materials into the body:

1. Foods and beverages are forbidden and are not to be consumed in areas where unsealed radioactive materials are stored or used. If any food or beverage containers are found in radioactive workplaces during unannounced RSO audits, they will be confiscated until they are determined not to be contaminated. Any foodstuffs will be discarded.
2. Smoking is not permitted in workplaces where radioactive materials are used. All smoking material found in radioactive work areas will be discarded.
3. Applying cosmetics while in radiation workplaces is prohibited.
4. All pipetting of radioactive materials shall be done by mechanical methods, i.e. not by mouth.
5. A fume hood shall be used for handling any radioactive material that may become airborne.

<sup>14</sup> Adapted from IAEA Safety Series No. 1 Safe Handling of Radionuclides 1973. The table was modified by using the values listed in Appendix C to 10 CFR 20 for each isotope and categorizing as indicated.

### 6.8.2 Shielding and Exposure Control Requirements

Requirements for shielding and/or remote handling devices will depend upon the external radiation levels of the specific radioisotopes and amounts to be handled. Specific requirements will be established by the RSO or RSC.

#### 1. In Controlled Areas

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

- a. 0.2 millirem per hour deep dose equivalent rate.
- b. 0.5 millirem per hour lens dose equivalent rate.
- c. 2 millirems per hour shallow dose equivalent rate.

Whenever dose rates in controlled areas are expected to be significantly above the design guidelines on a routine basis, remote area monitors, with alarm, will be installed to measure gamma and/or neutron dose rates, as appropriate.

#### 2. In Unrestricted Areas

Deep, lens and shallow dose equivalent rates at 5 centimeters from the boundaries of any adjacent controlled area should be well below 0.2 millirems in any one-hour. In addition, the total effective dose -equivalent (TEDE) to any member of the public should be well below 10 millirems in any year.

### 6.9 Radiation Control Techniques

The following are general procedures for radiation control in a radioisotope laboratory. Since each laboratory has special requirements, it is difficult to make one set of rules for all situations; however, with slight modifications the following can satisfy most needs.

1. Radiation work and storage areas shall be separate from general personnel spaces.
2. Personal belongings, other than those required for work, should not be brought into the laboratory.
3. Eating, drinking, smoking, and application of cosmetics in the laboratory shall be forbidden.
4. All work areas shall be covered with absorbent paper as a protection against spillage.
5. Necessary and appropriate shielding shall be provided.
6. Waste materials shall be placed in containers as specified in this manual.
7. Good housekeeping shall be maintained throughout the laboratory.
8. Restriction against all possible personal contamination shall be maintained.
  - Restrict public access.
  - Use appropriate signs.
  - Wear impervious gloves and use tongs.
  - Use remote pipetting technique.
  - Do not work when open skin wounds can be contaminated.

- Prohibit eating or drinking in radioactive areas.
  - Wear laboratory clothes over street clothes.
9. All contaminated glassware or equipment shall be clearly marked until it has been decontaminated.
  10. Work with volatile materials shall be restricted to special fume hoods, and work with radioactive powders shall be restricted to glove boxes.
  11. All radioactive materials, other than counting samples, should be kept away from counting areas.
  12. Work areas, materials, and/or containers shall be labeled as required by the regulations, or as a condition of the specific approval.
  13. Radiation use areas shall be surveyed with an appropriate survey technique, i.e. survey meter or wipe test (refer to Table 14), and the results of that survey documented at a frequency listed in Table 15 or as specified in the RUA.
  14. Where appropriate, radiation detection equipment should be used at all times during manipulations of unsealed radionuclides to detect and prevent the spread of contamination. Users should periodically check their gloves and forearms for contamination.
  15. If, in the course of work, contamination is suspected, the area shall be monitored with a suitable survey meter or by means of an "area wipe" and decontaminated if necessary.
  16. Before leaving the laboratory, hands should be washed and checked with a suitable survey meter.

#### **6.9.1 Additional Requirements for High and Very High Radiotoxicity Nuclides**

1. Pre-plan the operation in detail.
  - Provide shielding as required.
  - Decide actions required in case of emergencies.
  - Develop the personal skills necessary to satisfy the special needs of the project.
2. Inform personnel working with radioactive materials (and those who could be affected by incidental exposure or accidents) of safety practices and emergency procedures.
3. Personnel monitors are to be worn by all persons participating in a project when they are specified in the approval.
4. Use appropriate laboratory facilities and equipment.
5. Restrict procedures to one radioisotope and one operation at a time wherever possible. Avoid simultaneous and conflicting hazardous situations.
6. Monitor all areas and operations routinely.

#### **6.10 Laboratory Surveys**

While the majority of UCSC programs for radiation control rely on correct experimental design, the problem of contamination is most easily handled when appropriate contamination monitoring surveys are performed routinely by the designated user. Routine laboratory surveys are required

in research and teaching laboratories to detect excessive radiation and/or contamination levels in order to alert laboratory personnel to potential hazards.

The RSC requires all users of radiation to equip themselves with instruments capable of assessing ambient radiation levels and/or radioactive contamination levels of the radioisotopes to be used. Recommended surface contamination instruments are listed in Table 14.

**Table 14**  
**Recommended Contamination Detection Instruments**

Radiation Type	Energy	Isotope Example	Detector*
<b>Alpha</b>	All	Am-241, Cf-252	ZnS scintillation Proportional Wipe test – LSC
<b>Beta</b>	< 200 KeV	H-3, C-14, S-35	Wipe test – LSC
	≥ 200 KeV	P-33, P-32	Pancake GM Proportional Wipe test – LSC
<b>Gamma</b>	> 20 KeV	Cr-51, I-125	Thin NaI scintillation Wipe test – gamma well Wipe test - LSC
	≥ 20 KeV	Na-22, I-131	Thick NaI scintillation Wipe test – gamma well Wipe test - LSC

\* Other detectors may be substituted based on their ability to detect the radiation with an MDA below the limits specified in Table 17.

The frequency of user surveys is based on the Hazard Guide Value assigned to the individual experiment as indicated in Table 15. Table 16 lists the survey frequency by relative radiotoxicity based on the values in Table 15.

**Table 15**  
**Survey Frequency by Maximum HGV\***

Area	Monthly	Weekly	Daily
<b>Controlled Areas</b>	< 10	10 – 1000	> 1000
<b>Restricted Areas</b>	< 100	100 – 10,000	> 10,000

\* Based on total activity within the monitoring period. Monitoring does not need to be performed for the specified frequency period if no use of radioactive material has occurred. Quarterly monitoring will be required of all radiation use areas regardless of use.

**Table 16**  
**Survey Frequency by Maximum Activities Used (U=1) in Controlled Areas\***

Relative Radiotoxicity	Monthly	Weekly	Daily
5 – Very High	< 1 $\mu$ Ci	1 $\mu$ Ci – 100 $\mu$ Ci	> 100 $\mu$ Ci
4 – High	< 10 $\mu$ Ci	10 $\mu$ Ci – 1 mCi	> 1 mCi
3 – Moderate	< 100 $\mu$ Ci	100 $\mu$ Ci – 10 mCi	> 10 mCi
2 – Low	< 1 mCi	1 mCi – 100 mCi	> 100 mCi
1 – Slight	< 10 mCi	10 mCi – 1000 mCi	> 1 Ci

\* Based on total activity within the monitoring period. For use in restricted areas, the amounts above may be multiplied by 10. Monitoring does not need to be performed for the specified frequency period if no use of radioactive material has occurred. Quarterly monitoring will be required of all radiation use areas regardless of use.

### 6.10.1 Survey Records

Permanent records will be kept of all survey results, **including negative results**. The records will include:

1. Location, date, and type of equipment used.
2. Name of person conducting the survey.
3. Drawing of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.
4. Measured exposure rates and/or contamination levels keyed to location on the drawing.
5. Corrective action taken in case of contamination or excessive exposure rates, and the reduced contamination levels or exposure rates after corrective action.

### 6.11 Decontamination Requirements

During the course of work, laboratory surfaces, equipment, clothing, etc., may become contaminated in spite of precautions. Such contamination does not necessarily present a serious hazard, provided it is detected promptly and not allowed to spread or be ingested.

It is the responsibility of the RPI to see that decontamination is carried out properly and instruct personnel in decontamination procedures. EH&S Radiation Safety will provide assistance or supervision in cases of gross or personal contamination which the laboratory cannot handle themselves.

During a decontamination procedure, it is important to:

1. Wear appropriate protective clothing (gloves, lab coats, etc.).
2. Confine the spread of contamination (start from areas of low contamination and work towards higher contaminated areas).

3. Carefully remove all loose or easily removable contamination, followed by washing with soap, detergent, or special solvents.
4. Place all cleaning materials (absorbent materials, gloves, etc.) in a radioactive waste container.

Glassware and other contaminated equipment should be cleaned using laboratory detergents, acids, or cleaning solutions as appropriate. All equipment contaminated with long-lived radionuclides that cannot be cleaned to acceptable levels must be discarded as radioactive waste. Such glassware and equipment should be destroyed to prevent accidental return to stock or other use. Equipment contaminated with short-lived radionuclides and stored to allow for radioactive decay must be clearly identified and stored in a secure location.

Workplace surfaces and floors which cannot be decontaminated to acceptable levels must be a) treated to fix the radioactivity in place and shielded to bring exposure limits to an acceptable level, b) identified as a radiation area, or c) isolated to allow for radioactive decay or removed and disposed of as radioactive waste.

Levels of contamination on skin, clothing, radioactive work surfaces, equipment and facilities should be kept as low as reasonably achievable. Maximum acceptable limits of contamination that are considered safe are listed in Table 17.

#### **6.11.1 Tolerable Decontamination Levels**

Radioactive contamination should be maintained as low as possible and must not exceed the levels specified in Table 17. Compliance with these levels can be determined by the use of an appropriate survey meter or area wipe.

**Table 17**  
**UCSC Contamination Limits<sup>15</sup>**

TYPE OF SURFACE	Total  Includes Removable and Fixed Contamination  dpm/100cm <sup>2</sup>	$\alpha$ Emitters  dpm/100cm <sup>2</sup>	Removable	
			$\beta$ , X or $\gamma$ Emitters Radiotoxicity Level 3, 4, and 5 dpm/100cm <sup>2</sup>	$\beta$ , X or $\gamma$ Emitters Radiotoxicity Level 1 and 2 dpm/100cm <sup>2</sup>
<b>Restricted and Controlled Areas</b>				
Within posted radioactive materials zones	1,000 $\alpha$ 10,000 $\beta$ , X or $\gamma$	200	2,000	10,000
Outside posted radioactive materials zones	100 $\alpha$ 1,000 $\beta$ , X or $\gamma$	20	200	1,000
Skin, personal clothing and protective clothing	Below detectable limits			
<b>Unrestricted Areas</b>				
All surfaces including all items removed from restricted and controlled areas	Below detectable limits			

### 6.12 Radioactive Waste Management

The Radioactive Waste Management Program is designed to protect the individuals dealing with waste and the environment. All radioactive waste must be transferred to EH&S Radiation Safety for disposal. No radioactive materials are permitted to be discharged into the sanitary sewer, released into the air, or disposed in the regular trash.

Mixed wastes should be separate from other waste. A mixed waste is one that is a chemically hazardous waste as well as radioactive. Lead is an example of a chemically toxic waste, so lead pigs should not be combined with the other solid waste. If the waste contains any known hazardous constituent, those hazards need to be identified both on the *Radioactive Waste Tracking Form* and on the waste container.

Isotopes should not be mixed in single containers, if it can be avoided. Each isotope has a different half-life and decays at a different rate. Under the University's license, waste radioactive materials with half-lives shorter than 120 days can be safely disposed after the passage of 10 half-lives; the rest must be packaged for disposal by an outside contractor.

<sup>15</sup> Adapted from Table 2 from Reg. Guide 8.23, Jan '81.

To arrange pickup by EH&S, complete the *Radioisotope Waste Tracking Form*. One form goes with each container. Make sure to include all the information requested (see the specific instructions on filling out the Waste Tracking Form). Submit the form to EH&S Radiation Safety to request a pickup. EH&S Radiation Safety makes routine waste pickups.

### 6.12.1 General Considerations

When disposing of radioactive waste, recognize that other hazards can be present (e.g., biohazards, chemicals, sharps, etc.) and that each must be treated appropriately.

Personnel exposure and/or area contamination shall be avoided by shielding waste containers as required and minimizing the quantity of waste stored in labs.

Radioactive waste must NOT be placed in any ordinary trash receptacle.

Volume shall be reduced whenever possible. After monitoring, discard any uncontaminated material (e.g., packing material) in the ordinary trash or according to its other hazards as appropriate.

All radioactive material labels shall be removed or completely defaced from non-radioactive materials/packages when they are placed in the ordinary trash receptacle.

Other hazardous waste shall not be mixed with radioactive waste (e.g., no lead "pigs").

If a hazard can be eliminated legally at the point of generation, it should be (e.g., some biohazards can be eliminated by sterilization). Contact EH&S Radiation Safety for assistance (x9-2553).

Only waste containers provided or approved by EH&S that are chemically compatible with the material being collected shall be used.

### 6.12.2 Waste Labeling

All containers shall be labeled appropriately.

Before adding waste, attach a radioactive material label and, if appropriate, identify:

1. RPI's name
2. Date the waste was first placed into the container.
3. Isotope(s) present.
4. Amount of activity of each isotope.
5. Other hazardous materials present (e.g., organics, corrosives, toxics, etc.).

### 6.12.3 Solid Radioactive Waste

All solid radioactive waste must be placed in plastic-lined containers authorized by EH&S Radiation Safety. To protect personnel from injury, all hypodermic needles must be placed in a puncture-proof sharps container before being placed into the solid waste box for disposal. No liquids, animal remains, or active pathological agents are permitted in the solid waste containers.

### 6.12.4 Liquid Radioactive Waste

All liquid radioactive wastes shall be collected in EH&S Radiation Safety approved plastic carboys with tight screw caps. Fill containers only to 80% of capacity.

All liquids must be maintained at a pH between 6-9. Liquids containing iodine must be kept slightly basic (pH 8-10) to reduce the volatilization of radioiodine.

Aqueous and water-soluble materials must be placed in separate containers from non-aqueous materials, because of varying disposal site requirements.

All liquid waste containers shall be placed in secondary containers (e.g., plastic dish pans) of sufficient size to contain all of the liquid in the bottles in case of breakage or leakage.

Because of stringent local restrictions, no liquid radioactive materials are permitted to be discharged into the campus sanitary sewer system.

No solid materials or active pathological agents are permitted in liquid waste containers.

### 6.12.5 Animal Waste

All radioactively contaminated animal carcasses, tissues, and excreta must be placed in sealed double plastic bags.

Carcasses containing 0.05  $\mu\text{Ci}/\text{gram}$  or less of C-14 or H-3 are to be kept separate from all others and so labeled. All animal waste must be stored frozen, either in your lab or in a specially designated department freezer.

### 6.12.6 Liquid Scintillation Cocktail (LSC) Vials

LSC vials must be packaged separately from all other wastes, in EH&S-approved containers.

NO other material of any kind is to be included in the containers with LSC vials.

### 6.12.7 Other Wastes

In cases where radioactive material cannot be disposed of as outlined above, the EH&S Office should be consulted before the waste is generated. Special procedures may be required by the RSO and/or the RSC.

### 6.12.8 Segregation Scheme

In order to manage radioactive waste efficiently the waste must be segregated according to type at the point of generation as indicated below. All radioactive wastes are to be segregated according to their half-life. Specific instructions and Waste Disposal Tracking Forms are available from EH&S Radiation Safety.

1. Dry solid
  - a) Short half-life ( $T_{1/2} \leq 120$  days)
  - b) Long half-life ( $T_{1/2} > 120$  days)
2. Liquid
  - a) Short half-life
    - i. Aqueous based non-chemically hazardous
    - ii. Mixed waste
  - b) Long half-life
    - i. Aqueous based non-chemically hazardous
    - ii. Mixed waste
3. Liquid Scintillation Vials

- a) H-3 and/or C-14 liquid scintillation cocktails <0.05  $\mu\text{Ci/ml}$ .
- b) Other isotopes
4. Biological<sup>16</sup> (animal carcasses/medical waste)
  - a) Short half-life
  - b) Long half-life
  - c) H-3 and/or C-14 with <0.05  $\text{uCi/g}$  or  $\text{ml}$
5. Sharps (needles, broken glass, pipette tips)
  - a) Short half-life
  - b) Long half life
6. Stock vials (empty or full)
  - a) Short half-life
  - b) Long half-life
7. Sealed sources

The only exception(s) to the above segregation scheme should be mixtures that are produced as a result of a procedure/process. If there are questions, call EH&S Radiation Safety.

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<sup>16</sup> Must be frozen if held for more than 24 hours before pickup by EH&S Radiation Safety.

## 7 REQUIRED RECORDS

### 7.1 EH&S Radiation Safety Maintained Records

The RSO is responsible for the maintenance and control of all central record keeping requirements including the registration of sources of hazardous radiation, RUAs under the program, inventory of radioactive materials, disposals of radioactive waste, inspection reports, monitoring records and other records required by the State of California, NRC, and other enforcing agencies.

1. Application and Authorization - Copies of the original application and authorization must be kept on file at EH&S Radiation Safety.
2. Changes in Authorization - The RPI shall notify the RSO of any expected changes (i.e. possession, use, personnel or facilities) in authorized use. The RSO will then advise the user as to the proper procedures for obtaining approval of such changes.
3. RUA Status Report - At yearly intervals a copy of the RUA Status Report will be sent to each RPI. The form should be completed and returned to EH&S Radiation Safety (a copy will be retained by the RPI). The information contained on this form will enable the RSC to know the status of each project.
4. Personnel Records – Copies of *Training and Experience Forms* for each DU. Copies of all training documents. Declarations of pregnancy.
5. EH&S Radiation Safety Audits –The RSO shall maintain records of audits conducted in compliance with this manual. Records shall be maintained for a period of at least three years.
6. Dosimetry - Individuals that require personnel dosimetry will receive a yearly monitoring report from EH&S Radiation Safety that lists the exposure from external sources and internally deposited radioisotopes, as appropriate. EH&S Radiation Safety shall maintain dosimetry records.
7. Bioassay - The Radiation Safety Office shall maintain records of all bioassays conducted in compliance with Appendix V of this manual.
8. Leak Testing -The RSO shall maintain records of the results of leak tests of sealed sources.
9. Spills and Contamination – EH&S Radiation Safety shall be notified immediately of any major spills and/or gross contamination of facilities.
10. Training Records - EH&S Radiation Safety will keep copies of Training and Experience Forms.

### 7.2 RPI Maintained Records

Each RPI must maintain records in a laboratory binder (e.g., 3-ring binder titled *Radiation Safety Laboratory Records*). The journal is a necessary part of the records required by state regulations. It must be kept in the laboratory and be available for review by EH&S Radiation Safety and state inspectors at all times. It must contain the following information:

1. A copy of the approved RUA and any amendments to that application. The RUA will list any specific requirements or conditions of use.

2. A copy of this *Radiation Safety Manual* must be kept and made available to all designated users. (Access to the on-line version is acceptable.)
3. Copies of the RUA Status Report sent by EH&S Radiation Safety.
4. Documentation of “*On-the-Job*” training provided to lab personnel.
5. Copies of the *Radioactive Material Receipt and Use Log* indicating the receipt of each radioisotope (isotope, chemical, and/or physical form, quantity and date of receipt), including any radioactive materials transferred from one RPI to another.
6. Copies of the *Radioactive Material Receipt and Use Log* indicating the date, activity, and use of each withdrawal from stock.
7. Records of disposal of isotopes and contaminated lab material that indicate the date, activity, physical form, and method of disposal.
8. Copies of the *Quarterly Inventory Verification* reports.
9. Records of laboratory contamination self-surveys. Entries must include the date, person making the survey, the instrument or method used, location and levels of activity encountered. When required, it is important that a statement regarding the average exposure reading encountered in work areas be included in the record even when this value is essentially background. When the cause of high readings is known, it should be identified.
10. A complete history of and corrective action taken for any accident which involves a “major” spill.
11. Data necessary to demonstrate compliance with any special requirements placed on the specific authorization.

## 8 RADIATION PRODUCING MACHINES

Campus radiation machines are divided into five categories based on the hazards involved and the prevalence of the machines on campus. The five categories are:

1. Electron Microscopes
2. Medical Machines
3. Cabinet X-ray Machines
4. X-ray Diffraction and Fluorescence Analysis Machines
5. Miscellaneous Machines

General Regulations apply to all radiation machines while Specific Regulations apply only to certain categories.

### 8.1 General Regulations

#### 8.1.1 Possession

1. No radiation machines shall be brought onto campus without prior notification of the RSO. Approval to operate shall be obtained from the RSC and the RSO. This approval shall consider possible effects on others and their work, need for special shielding and any other pertinent items. Approval is required regardless of means of acquisition (e.g. purchase, lease, gift, loan, “in-house” fabrication) and regardless of ownership.
2. No radiation machines shall be removed from campus or deactivated without approval of the RSO. Any machine de-activated but left on campus must be marked “De-activated radiation machine. Do not move or re-activate without prior approval of the RSO.”
3. The Radiation Safety Officer shall notify the State of California Department of Health Services within thirty days of receipt, transfer or disposal of any radiation machine. The Radiation Safety Officer shall renew registration of all campus radiation machines as required.

#### 8.1.2 Use

1. No radiation machine shall be used except in strict compliance with a valid RUA. The RUA shall list the RPI, describe the machine, and specify (directly or by reference) the specific machine operators, operating parameters, procedures, locations, dosimetry, and the safety precautions that shall be used.
2. The RSO shall be notified of changes in personnel or machine location, and of machine repair. Prior approval by the RSO shall be obtained for machine modifications.
3. Safety interlocks shall never be used to deliberately terminate machine operation except for test purposes.

### **8.1.3 Personnel**

1. Each radiation machine shall be controlled by an RPI who is responsible for ensuring compliance by all operators with all applicable regulations. The RSC and the RSO shall approve each RPI. Approval requires adequate knowledge, and academic or staff stature sufficient to permit the RPI to obtain compliance by all operators.
2. Use of each machine shall be by or under direct supervision of an approved operator listed on the RUA and is contingent upon the person demonstrating adequate knowledge and ability for safe use of the machine. An authorized repairperson may operate a machine during setup, testing, and repair if prior permission from the RSO is obtained for each such use.

### **8.1.4 Radiation Exposures**

Radiation producing machines shall be used according to the instructions of the manufacturer such that:

1. The radiation exposure to operators and other individuals in the surrounding areas is as low as reasonably achievable.
2. The machine does not exceed the exposure limits specified in Part 4 of this manual.

### **8.1.5 Personal Protective Equipment**

In general, personal protective equipment (e.g., leaded aprons, gloves, and/or goggles) are useful only for low energy (less than about 100 kVp) X-ray sources. Recognizing this limitation, personal protective equipment should be used to protect any part of the body that may be exposed by a primary X-ray beam or wherever their exposure can be reduced significantly by their use, but not in place of other required engineering controls.

### **8.1.6 Machine Location**

As a general safety precaution and to provide security during unattended operation, it may be desirable to dedicate an entire room or area that can be secured to a radiation-producing machine. When this is not possible/desirable, the machine should be placed in an area out of the main traffic flow and away from high occupancy areas. Unless confined or limited by other means, primary beams shall be intercepted by a primary barrier and limited such that they cannot irradiate personnel. Scatter/secondary radiation shall be controlled such that the radiation exposure is as low as reasonably achievable, but in no case greater than the limits specified in this manual. With the exception of mobile X-ray and dental units, any change in location of a radiation producing machine must be approved by EH&S Radiation Safety.

### **8.1.7 Posting and Labeling**

1. All radiation machines shall be clearly and visibly labeled to caution individuals that such machines produce radiation when operated.
2. Radiation Areas as defined in section 6.6.2 of this manual shall be posted as required.
3. A copy of the Campus Radiation Producing Machine Safety Procedures shall be posted in the immediate vicinity of each machine.

### 8.1.8 Radiation Surveys

1. The RSO shall survey each machine before routine use, following any major changes in configuration or repairs, and at least on an annual basis.
2. The RPI or approved operator(s) shall survey the machine for radiation leakage as specified by the RUA.

### 8.1.9 Facility Review and Inspections

Plans for facilities that include radiation producing machines must be reviewed before they are put into operation and periodically thereafter to ensure that they are and remain safe and in compliance with appropriate federal, state, and local regulations.

Initial Review: EH&S Radiation Safety shall inspect any new or modified radiation producing machine or facility before its operation. The inspection is intended to determine if the facility/radiation-producing machine is safe for the intended use and that it complies with appropriate federal, state, and local regulations.

Periodic Inspections: Yearly, EH&S Radiation Safety shall inspect facilities that include radiation producing machines to ensure that they are in safe operating condition and in compliance with appropriate federal, state, and local regulations/requirements.

### 8.1.10 Radiation Monitoring Dosimetry

Individually assigned dosimeters and/or film badges supplied by the Office of EH&S shall be used when so specified by the RUA.

All individuals working in areas where the potential for exposure to radiation meets the criteria specified in the UCSC Radiation Safety Manual shall wear radiation monitors. Typically, any individual working with any radiation producing machine should wear personnel monitors. Exceptions include: standard electron microscopes, X-ray fluorescence units, and other self-contained low kV/mA machines. Required radiation monitors are available from EH&S Radiation Safety.

### 8.1.11 Safety Devices

Federal, state and local regulations for each radiation-producing machine require certain safety devices. Required safety devices include fail safe warning light, fail safe interlocks, beam enclosures, shielding, and radiation survey meters.

All safety devices shall be maintained in working order, and shall not be replaced or modified without specific approval by EH&S Radiation Safety. No safety device is absolutely fail-safe or foolproof and should act only as a back up, not as a replacement for proper procedures.

Safety devices must never be purposely defeated. If the design of a safety device makes a desired/necessary operation inconvenient or impossible, an alternate safety device/method shall be developed that provides the same degree of protection. Modified safety devices/methods shall be approved by EH&S Radiation Safety before operation of the radiation-producing machine. When safety devices are modified, it may be necessary to modify existing operating procedures and to retrain operators. If a required safety device fails, the machine shall not be operated until it is repaired, and subsequently checked, by EH&S Radiation Safety. EH&S Radiation Safety shall be notified immediately if an unexpected personnel radiation exposure occurs or is suspected.

No radiation producing machine shall be operated at any time unless all specified shielding and other safety devices are in place and functioning properly except when operated by an authorized repairperson.

#### 8.1.12 Operating Procedures

Operating procedures approved by EH&S Radiation Safety must be available in the work area to all users of radiation producing machines.

#### 8.1.13 Use Log

The purpose of a "Use Log" is to document the users, uses, and operating status of a machine. Information contained in this log can be useful when investigating incidents and/or determining the operating status/reliability of a machine. A "Use Log" shall be maintained for all radiation producing machines.

A "Use Log" shall include the following information for each time the machine is used: date of use, name of the operator, description of use, beam voltage, beam current, time beam turned on, time beam turned off, comments concerning operation abnormalities, repairs, etc.

### 8.2 Specific Regulations

#### 8.2.1 Electron Microscopes

Operators shall maintain an operating log.

#### 8.2.2 Medical Machines

1. Operators shall maintain an operating log as described in 8.1.13.
2. All machine operations, installation designs, etc., shall be in accordance with published State of California Department of Health Services regulations and recommendations of NCRP reports 33, 35, 49 and their successors, for human use.

#### 8.2.3 Cabinet X-Ray Machines and Fluorescence Analysis Machines

1. **Log:** Operators shall maintain an operating log as mentioned in 8.1.13.
2. **Enclosure:** Machines shall be used only in shielded boxes or rooms such that no radiation levels outside the shield exceed 0.2 mrem per hour, no person is within the shield at any time while the machine is producing X-rays, and all shield entrances are interlocked in some manner so that any attempt to enter will shut off the machine.
3. **X-Ray Indicators:**
  - a. Each machine shall be provided with a conspicuous fail-safe warning light or device that indicates whether the X-ray tube is energized. The device shall be placed near the X-ray tube assembly and shall be labeled "X-ray on."
  - b. There shall be a warning light or device labeled "X-ray on" near the switch that energizes the X-ray tube. This light or device should be of fail-safe design.
4. **Safety Device Approval:** The function of all interlocks, indicators, and other safety devices shall be checked and approved by the RSO prior to use.

## 8.2.4 X-Ray Diffraction

1. **Log:** Operators shall maintain an operating log as mentioned in 8.1.13.
2. **Procedures:** Normal operating and alignment procedures shall be documented and readily available.
3. **Beam Stop:** Each port shall have a beam stop in place that limits the dose rate immediately behind it to less than 0.2 mrem/hr at maximum settings.
4. **Unused Ports:** Unused ports shall be secured in such a way that tools are required to open them.
5. **X-Ray Indicators:**
  - a. There shall be a conspicuous fail-safe light or device near the X-ray tube assembly that indicates whether the tube is energized. It shall be labeled "X-ray on."
  - b. There shall be a light or device near the switch that energizes the X-ray tube that indicates whether the tube is energized. It shall be labeled "X-ray on" and should be of fail-safe design.
6. **Lock:** Each machine should have a key-operated power switch. The lock should be constructed so that the key cannot be removed during operation. The key shall not be left in the lock when the machine is not in operation.
7. **Beam Enclosure:** During routine operation, the primary beam path shall 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 or shutter so that the beam cannot be available unless the enclosure is in place.
8. **Shutter Interlock:** Each port should be provided with a beam shutter that is interlocked with the accessory apparatus coupling or collimator in such a way that the port will be open only if the coupling or collimator is in place. Such a device shall be provided if there is to be any operation without an interlocked beam enclosure.
9. **Shutter-Open Indicator:** Each port should be provided with a shutter-open indicator of fail-safe design. Such indicators shall be provided if there is to be any operation without an interlocked beam enclosure.
10. **Radiation Levels:** The radiation level outside a beam enclosure shall not exceed 0.2 millirem per hour.
11. **Survey Instrument:** An appropriate operable radiation survey instrument shall be easily accessible at all times to each machine while in use. This instrument shall be used to monitor each initial setup and each significant modification thereof for excessive leakage, unsuspected beams, and other hazardous radiation conditions.
12. **Safety Device Approval:** The function of all interlocks, indicators, and other safety devices shall be checked and approved by the RSO prior to use.
13. **Location:** Each machine shall be located so that personnel in the general area shall not be subjected to unnecessary radiation exposure.

### **8.2.5 Miscellaneous Machines**

1. All other machines not fitting in the above categories shall be classified as miscellaneous machines. Some examples would be: particle accelerators, demonstration Crookes' tubes, high voltage supplies, etc.
2. All specific regulations for such machines shall be listed on the RUA for the machine.
3. The specific regulations for miscellaneous machines shall be similar in nature to those required for the other four machine categories.

## **9 NON-IONIZING RADIATION**

### **9.1 Laser Safety Program**

The RSC has adopted pertinent sections of nationally recognized laser safety guidelines (ANSI Z136), which are in the Laboratory Safety Manual. The standards, controls, and exposure limits established there are considered the governing factors for the safety controls necessary for laser devices at UCSC. These procedures are in conformance with applicable state and federal laws.

The RSO is responsible for monitoring the adherence to these regulations.

### **9.2 Other Radiation Safety Programs**

Additional safety criteria covering other hazardous radiation sources will be added as part of or by reference to the Laboratory Safety Manual as programs are developed.



## 10 EMERGENCY PLANS

When a radiation emergency is accompanied by other hazards (fire, explosion, chemical exposure, or other event that endangers life and/or property), it is important to deal first with those hazards that have the greatest potential impact. In an educational setting the quantities and types of radiation used are such that, in general, response personnel (fire and medical) can deal with severe threats to life, health, and/or property without concern for the radiation present if 1) they respond with their usual personal protective equipment, and 2) are monitored for radiation contamination and decontaminated as necessary before leaving the site of the emergency.

Any spill or release of radioactive material must be controlled promptly. The responsibility for cleaning spills, or calling for experienced help, rests on the individuals working in the area involved and the designated user. Instructions for decontamination of minor spills and safe levels of contamination are specified in Section 6.11.

Under no circumstances should a laboratory person attempt to examine or clean up a *significant* spill of radioactive material. A significant spill is defined as an uncontrolled or inadvertent release of radioactive material that exceeds ten times (10X) the values listed in Appendix G. The clean-up techniques should be planned with the same care as is used in quantitative chemical analyses or in bacteriological handling of virulent organisms. Proper precautions taken immediately will protect human life, prevent environmental pollution, and reduce operational and financial losses.

The RSO shall be notified immediately of any accidents involving:

- Significant skin contamination.
- Ingestion of radioactivity by personnel.
- Unexpected personnel exposure.
- Severe contamination of equipment.
- Spread of contamination, or difficulty in cleaning up a contaminated area.
- The loss of radioactive materials or radiation producing machines.

### 10.1 Personnel Contamination

The RSO shall be immediately notified of any personnel contamination for evaluation of sustained exposure.

1. Take care of medical emergencies first. If health or life-threatening conditions exist, administer first aid as appropriate. Decontamination can occur when the victim is in stable condition.
2. Notify persons in the area to assist you. Instruct someone to dial **911**. Ask for radiation safety assistance.
3. For skin contamination, wash the contaminated area for two (2) minutes using a mild, pure soap and tepid (luke-warm) water. Pay particular attention to areas between fingers or around fingernails.
4. If the contamination is widespread, shower with mild soap and warm water, then resurvey to localize any remaining contamination.
5. If soap and water alone do not remove the contamination, repeat the two (2) minute wash up to three times unless the skin starts to turn red.
6. Once the contamination is localized, consider masking off the area with tape and cleaning with swabs. Rinse the contaminated area thoroughly, dry and count.

7. Contact the RSO as soon as possible.
8. Contaminated clothing should be bagged and turned over to EH&S Radiation Safety for storage to allow for radioactive decay, decontamination or disposal.

### **10.2 Major Spill (Greater than 10X Appendix G of the Radiation Safety Manual)**

1. Notify all persons not involved in the spill to vacate the room immediately.
2. Survey all personnel who could possibly have been contaminated; if contaminated, follow the procedures for personnel contamination above.
3. Dial **911**. Ask for radiation safety assistance.
4. When feasible, use reasonable effort to confine contamination. Restricting the movements of potentially contaminated persons to a local zone just outside the spill area until the extent of shoe and clothing contamination is ascertained can diminish the spread of radioactive contamination.
5. Close the room and lock or otherwise secure the area to prevent entry. Post the room with a sign to warn anyone trying to enter that a spill of radioactive material has occurred.
6. Wait until help arrives.
7. Allow no one to return to work in the area unless approved by the RSO.
8. Follow the instructions of the RSO and/or the RSO's staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

### **10.3 Minor Spills (Less than 10X Appendix G of the Radiation Safety Manual)**

1. Notify all persons in the area that a spill has occurred.
2. Permit only the minimum number of persons in the area necessary to deal with the spill.
3. Put on personal protective equipment as necessary.
4. Prevent the spread of contamination by covering the spill with absorbent paper. (Paper should be dampened if solids are spilled.)
5. Clean up the spill using absorbent paper, using a monitor to check the progress of the work.
6. Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Put contaminated gloves and any other contaminated disposable material in the bag.
7. Survey the area with a survey meter or other appropriate technique. Check the area around the spill for contamination. Also, check hands, clothing, and shoes for contamination. Monitor all persons involved in the decontamination process.
8. Record the event in the Laboratory Journal.
9. In the event personal contamination is found, follow the procedure for Personnel Contamination.
10. Report the incident to the Radiation Safety Officer (RSO) promptly if the event occurs in an unrestricted area.

#### **10.4 Radiation Producing Machines**

1. TURN OFF MACHINE. If possible, de-energize circuit breaker.
2. Call 911 and ask for radiation safety assistance.
3. Notify the laboratory supervisor and/or the Radiation Principal Investigator.
4. Record all pertinent information about the incident including operating voltage and current, exposure time, and distance from the radiation source.



## Appendix A Statutes and Regulations

The following statutes and regulations and all amendments thereto are applicable to the use of radioactive materials at UCSC and are expressly incorporated as part of this Radiation Safety Manual:

### Federal Statutes and Regulations

- A. U.S. Atomic Energy Act of 1954.
- B. U.S. Radiation Control for Health and Safety Act of 1968.
- C. National Environmental Policy Act of 1969.
- D. U.S. Atomic Energy Commission Regulations, Title 10, Code of Federal Regulations, Chapter I.
- E. U.S. Food and Drug Administration, Department of Health, Education and Welfare Regulations, Title 21, Code of Federal Regulations, Chapter I, Subchapter J.
- F. U.S. Department of Transportation Regulations, Title 49, Code of Federal Regulations, Chapter I, Parts 170 to 199.
- G. U.S. Environmental Protection Agency Regulations, Title 40, Code of Federal Regulations, Chapter I.
- H. U.S. Department of Labor, Title 29, Code of Federal Regulations, Part 1910.
- I. Regulations of Other Miscellaneous U.S. Government Agencies, Code of Federal Regulations, Titles 14, 39 and 46.

### California Statutes and Regulations

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

Many of these codes and regulations are available for reference at EH&S Radiation Safety and at the Government Publications section of the McHenry library.



## **Appendix B**

### **Bylaws of the Radiation Safety Committee**

#### **A. Authority**

The Radiation Safety Committee (RSC) is appointed by the Chancellor on an annual basis and advises the Chancellor and the Office of Environmental Health and Safety (EH&S) on campus policy. The RSC establishes programs and university policies on radiation safety.

The RSC is responsible for:

1. Ensuring that all individuals who work with, or near, radioactive material or radiation producing machines have sufficient training and experience to enable them to perform their duties safely, and in accordance with California regulations and the conditions of the license.
2. Ensuring that all uses of radioactive material and/or radiation producing machines are conducted in a safe manner and in accordance with the State of California regulations and the conditions of the license.

#### **B. Criteria for Committee Appointment**

1. The RSC shall be composed of not more than 10 nor less than 5 members exclusive of ex-officio members. At least three members shall be selected from the academic faculty, one from staff employees and one student, all of who are knowledgeable of the principles and practices for the control of the hazards of radiation and experienced in the use of radioisotopes and/or radiation producing machines. Every effort shall be made to have one member from each of the major natural sciences academic disciplines. One or more of these members may serve for more than one year at the discretion of the Chancellor.
2. Activities of the RSC are directed by its Chairperson. The Chair of the RSC shall be a member of the Academic Senate. The chair of the RSC may appoint subcommittees to examine and recommend approval or disapproval of RUA applications and renewals plus other duties as directed by the chair and authorized in the license.
3. Technical support members serve continuously. The Director of Environmental Health and Safety and the Radiation Safety Officer are such members and serve ex-officio.

#### **C. Responsibilities and Duties**

1. Advisory to the Chancellor and EH&S

The RSC reports to the Chancellor through the Dean of the Natural Sciences Division and advises the Chancellor on all matters relating to radiation safety. It also advises the office of EH&S in carrying out the Radiation Safety Program.

RSC members should be familiar with all pertinent California regulations, the terms of the license and information submitted in support of the request for the license and its amendments, as well as the contents of this Radiation Safety Manual.

2. Radiation Safety Manual

The RSC is responsible for the development of a Radiation Safety Manual, for its publication, distribution and revision as necessary, which sets forth campus policy in radiation safety. The

RSC will review all additions, deletions and changes and make recommendations for the Chancellor's approval and/or adoption. The manual shall include policy statements on:

- a. The scope of the radiation control program and the activities covered.
- b. Procedures to be followed in obtaining authorization to acquire and use radioisotopes and radiation producing machines.
- c. Regulations and procedures for the storage, transportation and disposal of radioactive materials.
- d. Responsibilities of RPIs for the control of radiation hazards.
- e. Maximum permissible radiation exposures to personnel.
- f. Minimum requirements for personnel monitoring.
- g. Minimum requirements for posting of radiation hazard warning signs.
- h. Procedures to be followed in emergencies involving radiation.

3. Authorization for Radiation Use

The RSC reviews and recommends approval for the acquisition, possession and use of radioisotopes and/or radiation producing machines. In determining approval of applications for permits to use radioisotopes and/or ionizing radiation machines the applications shall be supported by documentary evidence of:

- a. Adequate experience and training of the RPI.
- b. Proper and sufficient equipment and facilities.
- c. Adequate plans and procedures for storage, handling and disposal of radioactive material.
- d. Establishment of procedures to limit radiation exposure of personnel to as low as is reasonably achievable.
- e. Assurance that the minimum amount of radioactive material is used to achieve desired results.

4. Annual Review of Authorized Use

The RSC shall ensure that each RPI's authorized radiation use is completely renewed every three years with annual commitments that the procedures, equipment and personnel have not changed from the original application except by approved amendment requests. If deemed necessary, the RSC may recommend a more frequent review schedule.

5. Review of Environmental Health and Safety Activities

The RSC reviews and gives advice on the Campus Radiation Safety Program and related activities of the Office of EH&S. The Office of EH&S shall provide such reports, summaries and statistics as the RSC may require for its review. The Office of EH&S shall also bring to the attention of the RSC matters requiring changes in policy, standards or regulations.

- a. Ensure that the radioactive material license is amended, when necessary, before any changes in facilities, equipment, policies, procedures, and personnel.
- b. Ensures that EH&S Radiation Safety resources are adequate for its assigned duties.
- c. Review individual incidents and the radiation safety program to determine that all activities are being conducted safely and in accordance with California regulations and the conditions of the license. The review shall include an examination of pertinent records, reports from

the RSO, results of California inspections, written safety procedures and management control system.

- d. Recommend remedial action to correct any deficiencies identified in the radiation safety program.

#### 6. Information and Training of Users

The RSC will serve as a source of information on radiological safety, will disseminate pertinent information to all users or to individuals and will provide guidance in the training of users with regard to source materials, courses, and other means of improving the level of expertise.

- a. Establish a program to ensure that all individuals whose duties may require them to work in the vicinity of radioactive materials or radiation producing machines (e.g., clerical, emergency response, campus police, maintenance, and building services personnel) are properly instructed as required by CCR, Title 17, Section 30280.

#### 7. Meetings

- a. The RSC shall meet as often as required but at least quarterly for the purpose of reviewing radiation program activities and other matters related to the RSC charge.
- b. Special meetings may be called to review Radiation Use Authorizations, review and act on radiation incidents and/or consider matters referred by the Radiation Safety Officer or members of the RSC.
- c. A quorum, consisting of a simple majority of the membership, shall be present at all meetings and will include the Radiation Safety Officer or his designated alternate.
- d. Minutes of the meetings, actions, recommendations, and decisions shall be recorded by a member of the Office of EH&S. Copies of the minutes shall be sent to members of the RSC. The Office of EH&S shall maintain a file of the minutes.



## **Appendix C**

### **Responsibilities of the Radiation Safety Officer (RSO)**

The RSO administers the EH&S Radiation Safety Program under the general direction of the RSC. Specifically, his/her duties include the following:

1. Communicates the federal/state requirements for the safe use of radiation.
2. Prepares a Radiation Safety Manual to serve as a statement of UCSC policy and practice regarding the use of ionizing radiation.
3. Is the liaison between UCSC and federal/state regulatory agencies.
4. Directs the functions of EH&S Radiation Safety.
5. Oversees radioactive waste disposal activities.
6. Reviews applications for new or modified uses of radioactive materials and radiation producing machines prior to their use.
7. Reviews projects and inspects facilities to determine the level of compliance with the pertinent regulations and any conditions specified by the RSC.
8. Investigates incidents and, where necessary, directs corrective action.
9. Develops emergency response plans, operational procedures and coordinates radiation-related activities during an emergency.
10. Provides services through EH&S Radiation Safety, including personnel and area monitoring, instrument calibration, waste disposal, facility design and project planning when radioactive materials and radiation-producing machines are involved.
11. Maintains appropriate records of EH&S Radiation Safety operations for inspection by appropriate agencies.
12. Conducts training programs and in-service updates.
13. Serves as secretary to and maintains records for the RSC.
14. Carries out any other activity assigned by the RSC.
15. The RSO, if other than the Director, shall make periodic reports to the Director of EH&S.



## **Appendix D**

### **Functions of EH&S Radiation Safety**

1. General surveillance of all health physics activities, including both personnel and environmental monitoring.
2. Furnish consulting services to personnel at all levels of responsibility on all aspects of radiation protection.
3. Receive and inspect all radioisotopes that come to UCSC and consult on all packages of radioisotopes shipped from UCSC.
4. Inspect all machines capable of producing ionizing radiation annually or as requested/needed.
5. Provide a personnel monitoring service as required, and maintain records of personnel exposure/uptake. Notify individuals and their supervisors of doses approaching or exceeding the UCSC Administrative Guidelines and recommend appropriate remedial action.
6. Assist with the training of university personnel who use radioactive materials. Topics should include basic radiation/health physics and training should utilize formal classroom courses and/or instructional aids.
7. Oversees the radioactive waste disposal program (includes pickup, storage, and maintaining disposal records).
8. Perform sealed source leak tests as required.
9. Maintain an inventory of all radioactive materials located at UCSC or its associated facilities.
10. Supervise decontamination efforts as required.
11. Maintain a program of environmental monitoring/remediation for radiation hazards.
12. Prepare radiation use applications/amendments for review by the RSC.
13. Review RUAs on an annual basis.



## Appendix E

### Responsibilities of the Radiation Principal Investigator (RPI)

The RPI is personally responsible for compliance with campus and governmental regulations as they pertain to the authorized use of radiation. Specific responsibilities include:

1. Apply to the RSC for authorization to use sources of ionizing radiation.
2. Prepare a plan before an experiment is conducted in order to determine the appropriate types and amounts of radiation or radioactive material necessary for the procedure. This will provide an indication of the level of protection required. Before a protocol is implemented, it may be desirable to do a dry run that will help to identify any unexpected problems. If problems are encountered, contact the RSO before initiating the procedure.
3. Maintenance of current records regarding:
  - A. Receipt, use and disposal of radioisotopes.
  - B. Monitoring of laboratories and workplaces including contamination levels and exposure data.
  - C. Personnel engaged in radioisotope use under their jurisdiction.
4. Have required records available for inspection at reasonable times by the RSO or the State Department of Health Services.
5. Train personnel under the RPI's supervision. This training shall include:
  - A. The requirement to read and understand:
    - a. The appropriate Radiation Use Authorizations
    - b. Pertinent laboratory instructions for the use of radioisotopes
    - c. The State Notice to Employees - Standards for Protection Against Radiation
    - d. The Campus Radiation Safety Manual
  - B. The proper procedures for the control of radiation hazards and limiting exposure to others according to the type of radioactive materials being used.
  - C. Ensure that all untrained personnel attend the general training session on radiation safety provided by EH&S Radiation Safety.
6. Inform the RSO when individuals, activities, or locations covered by an RUA are changed.
7. Implement approved procedures for the procurement of radioactive materials by purchase or transfer.
8. Post areas where radioactive materials are stored or used.
9. When required, post areas where radiation exposures exist.
10. Properly record the receipt, transfer and disposal of radioactive material, including sealed sources.
11. Properly store and prepare radioactive waste for collection by EH&S.
12. Enforce the submission of any required bioassay samples or keeping appointments for required organ scanning.
13. Conduct surveys of workplaces where authorized use of ionizing radiation is performed. The results of these surveys should be kept on file.
14. Maintain work areas free of removable contamination and providing personnel for decontamination operations.

15. Minimize the stock of stored radioactive materials within the work/laboratory area.
16. When terminating a RUA:
  - a. Transfer excess radioactive materials and personnel monitoring devices to EH&S Radiation Safety.
  - b. If radioactive waste is present, arrange for a pickup with EH&S Radiation Safety.
  - c. Conduct a lab survey to ensure that the area is free of contamination.
  - d. Request that EH&S Radiation Safety perform a close-out survey before leaving the campus.
17. Ensure that a copy of the Radiation Safety Manual is available to all personnel engaged in work with ionizing radiation.
18. Enforce the use of personnel monitoring devices, survey meters, personnel protective equipment, and engineering controls as specified in the Radiation Safety Manual or by the RSC.
19. Notify EH&S Radiation Safety immediately in cases of personnel contamination or excessive radiation exposure accidents or after any unusual event that results in contamination of work areas or release of radioisotope or radiation beyond the confines of the authorized work areas.

## Appendix F

### Responsibilities of the Designated User (DU)

Designated users who handle radioactive materials or use radiation producing machines are responsible for their own safety and the safety of those around them by:

1. Following procedures/protocols and ensuring that training and safety equipment, etc., are adequate. Check with the RPI or RSO if there are questions.
2. Keeping exposure to radiation as low as reasonably achievable, but also below the UCSC Administrative Guidelines specified in this manual.
3. Minimizing airborne radioactive contamination by use of available engineering controls such as fume hoods.
4. Wearing personal protective equipment (PPE).
5. Wearing prescribed monitoring equipment, such as film badges and ring badges when required.
6. Informing the RPI and/or RSO of any unsafe conditions known to exist.
7. Observing radiation control techniques.

The following are general procedures for radiation control in a radioisotope laboratory. Since each laboratory has special requirements, it is difficult to establish one set of procedures for all situations; however, with slight modifications the following can satisfy most needs:

Radiation work and storage areas must be separated from general personnel spaces.

- a) Personal belongings other than those required for work should not be brought into the laboratory.
- b) Eating, drinking, smoking, and application of cosmetics in the laboratory are forbidden.
- c) Cover all work areas with absorbent paper as a protection against spillage.
- d) Provide necessary shielding.
- e) Place waste materials in containers as specified in this manual.
- f) Maintain good housekeeping throughout the laboratory.
- g) Restrict against all possible personal contamination.
  - Wear rubber gloves and use tongs.
  - Use remote pipetting techniques.
  - Do not work when open skin wounds can be contaminated.
  - Prohibit lunchroom activities in radioactive areas.
  - Wear laboratory clothes over street clothes.
- h) Clearly mark all contaminated glassware or equipment until it has been decontaminated.
- i) Restrict volatile materials to special fume hoods, and powders to glove boxes.
- j) Keep all intermediate levels of radioactive materials away from counting areas.
- k) Label work areas, materials, and/or containers as required by law.

- l) Learn what instruments are effective for monitoring, and how to use them. Then monitor any suspect equipment or operation to ensure safety. You cannot know it is safe unless you have monitored it.
- m) If, in the course of work, contamination is suspected, check with a suitable survey meter or by means of an "area wipe" and decontaminate if necessary.
- n) Wash hands and check with suitable survey meter before leaving laboratory.

Additional Requirements for High Hazard Procedures (See Appendix G, Hazard Categories III and IV)

1. Pre-plan operation in detail:
  - a) Provide shielding as required.
  - b) Predetermine action in case of emergencies.
  - c) Develop personnel qualifications to satisfy the special needs of the project.
2. Inform personnel working with radioactive materials (and those who could be affected by incidental exposure or accidents) of safety practices and emergency procedures.
3. Use appropriate laboratory facilities and equipment.
4. Restrict procedures to one radioisotope and one operation at a time whenever possible. Avoid simultaneous and conflicting hazardous situations.
5. Monitor all areas and operations routinely.

## Appendix G Exempt Quantities<sup>17</sup>

Quantity Radionuclide	( $\mu$ Ci)	Quantity Radionuclide	( $\mu$ Ci)	Quantity Radionuclide	( $\mu$ Ci)	Quantity Radionuclide	( $\mu$ Ci)
H-3	1,000	Fe-60	1	Se-73m	1,000	Y-90	10
Be-7	*100	Co-55	100	Se-73	100	Y-91m	1,000
Be-10	1	Co-56	10	Se-75	*10	Y-91	10
C-11	1,000	Co-57	100	Se-79	100	Y-92	100
C-14	100	Co-58m	*10	Se-81m	1,000	Y-93	100
F-18	1,000	Co-58	*10	Se-81	1,000	Y-94	1,000
Na-22	*1	Co-60m	1,000	Se-83	1,000	Y-95	1,000
Na-24	*10	Co-60	1	Br-74m	1,000	Zr-86	100
Mg-28	100	Co-61	1,000	Br-74	1,000	Zr-88	10
Al-26	10	Co-62m	1,000	Br-75	1,000	Zr-89	100
Si-31	*100	Ni-56	100	Br-76	100	Zr-93	1
Si-32	1	Ni-57	100	Br-77	1,000	Zr-95	10
P-32	10	Ni-59	100	Br-80m	1,000	Zr-97	*10
P-33	100	Ni-63	100	Br-80	1,000	Nb-88	1,000
S-35	100	Ni-65	*100	Br-82	*10	Nb-89 (66 min)	1,000
Cl-36	10	Ni-66	10	Br-83	1,000	Nb-89 (122 min)	1,000
Cl-38	*10	Cu-60	1,000	Br-84	1,000	Nb-90	100
Cl-39	1,000	Cu-61	1,000	Kr-74	1,000	Nb-93m	10
Ar-39	1,000	Cu-64	*100	Kr-76	1,000	Nb-94	1
Ar-41	1,000	Cu-67	1,000	Kr-77	1,000	Nb-95m	100
K-40	100	Zn-62	100	Kr-79	1,000	Nb-95	*10
K-42	*10	Zn-63	1,000	Kr-81	1,000	Nb-96	100
K-43	1,000	Zn-65	10	Kr-83m	1,000	Nb-97	*10
K-44	1,000	Zn-69m	100	Kr-85m	1,000	Nb-98	1,000
K-45	1,000	Zn-69	1,000	Kr-85	*100	Mo-90	100
Ca-41	100	Zn-71m	1,000	Kr-87	*10	Mo-93m	100
Ca-45	*10	Zn-72	100	Kr-88	1,000	Mo-93	10
Ca-47	*10	Ga-65	1,000	Rb-79	1,000	Mo-99	100
Sc-43	1,000	Ga-66	100	Rb-81m	1,000	Mo-101	1,000
Sc-44m	100	Ga-67	1,000	Rb-81	1,000	Tc-93m	1,000
Sc-44	100	Ga-68	1,000	Rb-82m	1,000	Tc-93	1,000
Sc-46	10	Ga-70	1,000	Rb-83	100	Tc-94m	1,000
Sc-47	100	Ga-72	*10	Rb-84	100	Tc-94	1,000
Sc-48	*10	Ga-73	1,000	Rb-86	*10	Tc-96m	1,000
Sc-49	1,000	Ge-66	1,000	Rb-87	*10	Tc-96	*10
Ti-44	1	Ge-67	1,000	Rb-88	1,000	Tc-97m	100
Ti-45	1,000	Ge-68	10	Rb-89	1,000	Tc-97	*100
V-47	1,000	Ge-69	1,000	Sr-80	100	Tc-98	10
V-48	*10	Ge-71	*100	Sr-81	1,000	Tc-99m	*100
V-49	1,000	Ge-75	1,000	Sr-83	100	Tc-99	*10
Cr-48	1,000	Ge-77	1,000	Sr-85m	1,000	Tc-101	1,000
Cr-49	1,000	Ge-78	1,000	Sr-85	*10	Tc-104	1,000
Cr-51	1,000	As-69	1,000	Sr-87m	1,000	Ru-94	1,000
Mn-51	1,000	As-70	1,000	Sr-89	*1	Ru-97	1,000
Mn-52m	1,000	As-71	100	Sr-90	0.1	Ru-103	*10
Mn-52	*10	As-72	100	Sr-91	*10	Ru-105	*10
Mn-53	1,000	As-73	100	Sr-92	*10	Ru-106	1
Mn-54	*10	As-74	*10	Y-86m	1,000	Rh-97	*100
Mn-56	*10	As-76	*10	Y-86	100	Rh-99m	1,000
Fe-52	100	As-77	100	Y-87	100	Rh-99	100
Fe-55	100	As-78	1,000	Y-88	10	Rh-100	100
Fe-59	10	Se-70	1,000	Y-90m	1,000	Rh-101m	1,000

<sup>17</sup> This list is compiled from 10 CFR 20 Appendix C and from 17 CCR Section 30235 Schedule A. \* Values indicated with an asterisk are taken from 17 CCR Section 30235 Schedule A Exempt Quantities that are more restrictive than federal limits.

Quantity Radionuclide	( $\mu\text{Ci}$ )	Quantity Radionuclide	( $\mu\text{Ci}$ )	Quantity Radionuclide	( $\mu\text{Ci}$ )	Quantity Radionuclide	( $\mu\text{Ci}$ )
Rh-101	10	Sn-128	1,000	Xe-127	1,000	Ho-166	*100
Rh-102m	10	Sb-115	1,000	Xe-129m	1,000	Er-169	*100
Rh-102	10	Sb-116m	1,000	Xe-131m	1,000	Er-171	*100
Rh-103m	*100	Sb-116	1,000	Xe-133m	1,000	Tm-170	*10
Rh-105	100	Sb-117	1,000	Xe-133	*100	Tm-171	*10
Rh-106m	1,000	Sb-118m	1,000	Xe-135m	1,000	Yb-175	*100
Rh-107	1,000	Sb-119	1,000	Xe-135	*100	Lu-177	*100
Pd-100	100	Sb-120 (16 m)	1,000	Xe-138	1,000	Hf-181	*10
Pd-101	1,000	Sb-120 (5.76 d)	100	Cs-125	1,000	Ta-182	*10
Pd-103	100	Sb-122	100	Cs-127	1,000	W-181	*10
Pd-107	10	Sb-124m	1,000	Cs-129	1,000	W-185	*10
Pd-109	100	Sb-124	10	Cs-130	1,000	W-187	*100
Ag-102	1,000	Sb-125	*10	Cs-131	1,000	Re-186	*100
Ag-103	1,000	Sb-126m	1,000	Cs-132	100	Re-188	100
Ag-104m	1,000	Sb-126	100	Cs-134m	*100	Re-189	100
Ag-104	1,000	Sb-127	100	Cs-134	*1	Os-180	1,000
Ag-105	*10	Sb-128 (10.4 m)	1,000	Cs-135m	1,000	Os-181	1,000
Ag-106m	100	Sb-128 (9.01 h)	100	Cs-135	*10	Os-182	100
Ag-106	1,000	Sb-129	100	Cs-136	10	Os-185	*10
Ag-108m	1	Sb-130	1,000	Cs-137	10	Os-189m	1,000
Ag-110m	*1	Sb-131	1,000	Cs-138	1,000	Os-191m	*100
Ag-111	100	Te-116	1,000	Ba-126	1,000	Os-191	100
Ag-112	100	Te-121m	10	Ba-128	100	Os-193	100
Ag-115	1,000	Te-121	100	Ba-131m	1,000	Os-194	1
Cd-104	1,000	Te-123m	10	Ba-131	*10	Ir-182	1,000
Cd-107	1,000	Te-123	100	Ba-133m	100	Ir-184	1,000
Cd-109	1	Te-125m	10	Ba-133	*10	Ir-185	1,000
Cd-113m	0.1	Te-127m	10	Ba-135m	100	Ir-186	100
Cd-113	100	Te-127	*100	Ba-139	1,000	Ir-187	1,000
Cd-115m	10	Te-129m	10	Ba-140	*10	Ir-188	100
Cd-115	100	Te-129	*100	Ba-141	1,000	Ir-189	100
Cd-117m	1,000	Te-131m	10	Ba-142	1,000	Ir-190m	1,000
In-117	1,000	Te-131	100	La-131	1,000	Ir-190	100
In-109	1,000	Te-132	10	La-132	100	Ir-192m	1
In-110m (69.1 m)	1,000	Te-133m	100	La-135	1,000	Ir-192	10
In-110m (4.9 h)	1,000	Te-133	1,000	La-137	10	Ir-194m	10
In-111	100	Te-134	1,000	La-138	100	Ir-194	100
In-112	1,000	I-120m	1,000	La-140	*10	Ir-195m	1,000
In-113m	*100	I-120	100	Ce-141	*100	Ir-195	1,000
In-114m	10	I-121	1,000	Ce-143	100	Pt-186	1,000
In-115m	*100	I-123	100	Ce-144	1	Pt-188	100
In-115	*10	I-124	10	Pr-142	*100	Pt-189	1,000
In-116m	1,000	I-125	1	Pr-143	*100	Pt-191	100
In-117m	1,000	I-126	1	Nd-147	*100	Pt-193m	100
In-117	1,000	I-128	1,000	Nd-149	*100	Pt-193	*100
In-119m	1,000	I-129	*0.1	Pm-147	*10	Pt-195m	100
Sn-110	100	I-130	10	Pm-149	*10	Pt-197m	*100
Sn-111	1,000	I-131	1	Sm-151	*10	Pt-197	100
Sn-113	*10	I-132m	100	Sm-153	*100	Pt-199	1,000
Sn-117m	100	I-132	*10	Eu-152 (13 y)	*1	Pt-200	100
Sn-119m	100	I-133	*1	Eu-153 (9.2 h)	*100	Au-193	1,000
Sn-121m	100	I-134	*10	Eu-154	*1	Au-194	100
Sn-121	1,000	I-135	*10	Eu-155	*10	Au-195	10
Sn-123m	1,000	Xe-120	1,000	Gd-153	*10	Au-198m	100
Sn-123	10	Xe-121	1,000	Gd-159	*100	Au-198	100
Sn-125	10	Xe-122	1,000	Tb-160	*10	Au-199	100
Sn-126	10	Xe-123	1,000	Dy-165	*10	Au-200m	100
Sn-127	1,000	Xe-125	1,000	Dy-166	*100	Au-200	1,000

Quantity Radionuclide	( $\mu\text{Ci}$ )	Quantity Radionuclide	( $\mu\text{Ci}$ )	Quantity Radionuclide	( $\mu\text{Ci}$ )	Quantity Radionuclide	( $\mu\text{Ci}$ )
Au-201	1,000	Bi-214	100	U-238	100	Cm-246	0.001
Hg-193m	100	Po-203	1,000	U-239	1,000	Cm-247	0.001
Hg-193	1,000	Po-205	1,000	U-240	100	Cm-248	0.001
Hg-194	1	Po-207	1,000	U-natural	*50	Cm-249	1,000
Hg-195m	100	Po-210	0.1	Np-232	100	Bk-245	100
Hg-195	1,000	At-207	100	Np-233	1,000	Bk-246	100
Hg-197m	100	At-211	10	Np-234	100	Bk-247	0.001
Hg-197	*100	Rn-220	1	Np-235	100	Bk-249	0.1
Hg-199m	1,000	Rn-222	1	Np-236 (1.15E5 y)	0.001	Bk-250	10
Hg-203	*10	Fr-222	100	Np-236 (22.5 h)	1	Cf-244	100
Tl-194m	1,000	Fr-223	100	Np-237	0.001	Cf-246	1
Tl-194	1,000	Ra-223	0.1	Np-238	10	Cf-248	0.01
Tl-195	1,000	Ra-224	0.1	Np-239	100	Cf-249	0.001
Tl-197	1,000	Ra-225	0.1	Np-240	1,000	Cf-250	0.001
Tl-198m	1,000	Ra-226	*0.01	Pu-234	10	Cf-251	0.001
Tl-198	1,000	Ra-227	1,000	Pu-235	1,000	Cf-252	0.001
Tl-199	1,000	Ra-228	0.1	Pu-236	0.001	Cf-253	0.1
Tl-200	*100	Ac-224	1	Pu-237	100	Cf-254	0.001
Tl-201	*100	Ac-225	0.01	Pu-238	0.001	Es-250	100
Tl-202	100	Ac-226	0.1	Pu-239	0.001	Es-251	100
Tl-204	*10	Ac-227	0.001	Pu-240	0.001	Es-253	0.1
Pb-195m	1,000	Ac-228	1	Pu-241	0.01	Es-254m	1
Pb-198	1,000	Th-226	10	Pu-242	0.001	Es-254	0.01
Pb-199	1,000	Th-227	0.01	Pu-243	1,000	Fm-252	1
Pb-200	100	Th-228	0.001	Pu-244	0.001	Fm-253	1
Pb-201	1,000	Th-229	0.001	Pu-245	100	Fm-254	10
Pb-202m	1,000	Th-230	0.001	Am-237	1,000	Fm-255	1
Pb-202	10	Th-231	100	Am-238	100	Fm-257	0.01
Pb-203	1,000	Th-232	100	Am-239	1,000	Md-257	10
Pb-205	100	Th-234	10	Am-240	100	Md-258	0.01
Pb-209	1,000	Th-natural	*50	Am-241	0.001		
Pb-210	0.01	Pa-227	10	Am-242m	0.001	Any alpha emitting	
Pb-211	100	Pa-228	1	Am-242	10	radionuclide not listed above	
Pb-212	1	Pa-230	0.1	Am-243	0.001	or mixtures of alpha emitters	
Pb-214	100	Pa-231	0.001	Am-244m	100	of unknown composition.	
Bi-200	1,000	Pa-232	1	Am-244	10		0.001
Bi-201	1,000	Pa-233	100	Am-245	1,000		
Bi-202	1,000	Pa-234	100	Am-246m	1,000	Any radionuclide other than	
Bi-203	100	U-230	0.01	Am-246	1,000	alpha emitting radionuclides	
Bi-205	100	U-231	100	Cm-238	100	not listed above, or mixtures	
Bi-206	100	U-232	0.001	Cm-240	0.1	of beta emitters of unknown	
Bi-207	10	U-233	0.001	Cm-241	1	composition.	0.01
Bi-210m	0.1	U-234	0.001	Cm-242	0.01		
Bi-210	1	U-235	0.001	Cm-243	0.001		
Bi-212	10	U-236	0.001	Cm-244	0.001		
Bi-213	10	U-237	100	Cm-245	0.001		



## Appendix H Forms

The following lists some of the more commonly used forms needed by radiation users. Copies of the forms are available online at the Radiation Safety's web site <http://ehs.ucsc.edu/rs>.

1. **RUA Application - Radioactive Materials**
2. **RUA Application - Ionizing Radiation Producing Machines**
3. **SOP - Radioactive Materials**
4. **Statement of Training and Experience**
5. **Authorization to Release Personnel Dosimetry Records**
6. **RUA Amendment Request**
7. **RUA: Radioisotope Use Authorization**
8. **RUA: Status Report**
9. **Personnel Monitoring Record**
10. **Prenatal Radiation Exposure Risks and Precautions**
11. **Notification of Status as a Declared Pregnant Woman**
12. **Radioisotope Waste Tracking Form**



## Appendix I Animal Use

For all program proposals using radioactive materials in animal research, an integral part of the consideration for approval will be the Principal Investigator's assurance of safe handling and disposal of radioactive materials in biological specimens.

The Chancellor's Animal Research Committee (CARC) adopts the NIH Guide for the Care and the Use of Laboratory Animals in Research [HEW (NIH) 78-23, revised 1978]. Part H of the Guide, "Special Requirements for Radiation Safety," is to be considered as part of this manual as are the General Instructions for Animal Caretakers given below.

Where animal studies are involved, special care by animal caretakers and technical personnel is required to be certain of compliance. Specific instructions may be recommended by the RSC and will accompany approval of usage by the RSO and the Campus Veterinarian.

### GENERAL INSTRUCTIONS FOR ANIMAL CARETAKERS

General instructions for animal caretakers are listed below. Specific instructions will depend on the program, isotope, levels of activity, frequency of use and number of animals.

1. No animal use involving radioactive materials will occur without prior review by CARC, the RSC and approval by the RSO. Approval is partly contingent on assurances that adequate provision has been made for waste disposal and that appropriate instructions relevant to that particular isotope and use have been given to the animal caretakers and technicians.
2. All disposals will be through or under the supervision of the Radiation Safety Officer who will outline appropriate arrangements to guarantee compliance.
3. All equipment housing biological specimens will be placed in isolated areas or quarters, with the appropriate radiation sign(s) displayed.
4. Racks and cages housing animals administered radioactive materials will be so labeled. Information on the outside of the cage will include the date of administration, the isotope and the quantity administered.
5. Animals producing excreta having detectable radioactive activity are to be separated from those that do not.
6. Animal caretakers must be aware of specific instructions outlined in the usage proposal and any recommendations supplemented by the RSC.
7. Regular inspections will be carried out by the RSO and, when required, training sessions will be held by appropriate personnel assigned by the Director of EH&S and in cooperation with the Campus Veterinarian to ensure proper handling of radioactive materials by technicians, animal caretakers and supervisory personnel.



## Appendix J

### Glossary of Terms

#### **Airborne Radioactive Material**

Radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases. [10 CFR 20.1004]

#### **ALARA (As Low As Reasonably Achievable)**

Making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations and in relation to utilization of nuclear energy and licensed materials in the public interest. [10 CFR 20.1003]

#### **Cabinet X-Ray Machines**

Machines 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 and X-ray diffraction and fluorescence analysis machines.

#### **Controlled Area**

*Controlled area* means an area, outside of a restricted area but inside the site boundary, access to which is limited by the licensee for any reason. [10 CFR 20.1003]

At UCSC, all areas designated for use or storage of radioactive materials are designated controlled areas. Non-occupational exposed individuals may be present in these areas.

#### **Curie**

A unit of radioactivity. One curie is the activity corresponding to a disintegration rate of  $3.7 \times 10^{10}$  disintegrations per second.

#### **DHS (Department of Health Services)**

Reference to DHS means the California State Department of Health Services.

#### **Dose**

*Dose* or *radiation dose* is a generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in other paragraphs of this section. [10 CFR 20.1003]

#### **Declared Pregnant Woman**

A woman who has voluntarily informed the licensee, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant. [10 CFR 20.1003]

#### **Designated User (DU)**

An individual who is listed on an RUA as a user of radiation and has been properly trained to use the sources being used.

**Electron Microscope**

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

**EH&S**

Environmental Health and Safety at UCSC.

**Engineering Controls**

Safety features included as an integral part of a lab or other facility. Examples include increased ventilation, fume hoods, radiation shielding, safety interlocks, etc.

**Fail-Safe:**

A term that describes a type of design. A fail-safe indicator or light is designed such that, if it fails, the action, which it indicates, will automatically cease. Example: If a fail-safe “X-ray on” light burns out, X-rays will automatically cease to be produced.

**HGV**

Hazard guide value.

**High Radiation Area**

An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates. [10 CFR 20.1003]

**Human Use**

The internal or external administration of radiation or radioactive materials to human beings. [17 CCR §30100]

**Ionizing Radiation**

Ionizing radiation means gamma rays and X-rays; alpha and beta particles, high speed electrons, neutrons, protons, and other nuclear particles; but not sound or radio waves, or visible, infrared or ultraviolet light. [17 CCR §30100]

**Member of the Public**

Any individual except when that individual is receiving an occupational dose. [10 CFR 20.1003]

**Medical Machine**

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

**Minor**

An individual less than 18 years of age. [10 CFR 20.1003]

**NCRP**

National Council of Radiation Protection

**NRC**

The Nuclear Regulatory Commission or its duly authorized representatives. [10 CFR 20.1003]

**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**.

**Occupational Dose**

The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the public. [10 CFR 20.1003]

**Personnel Monitoring Equipment**

Devices designed to be worn or carried by an individual for the purpose of measuring the dose received by that individual (e.g., film badges, pocket chambers, pocket dosimeters, film rings, etc.).

**Personal Protective Equipment (PPE)**

Safety equipment used by an individual to protect him/her self from expected or unexpected hazards associated with a procedure. Examples include gloves, goggles, shoe covers, respirators, etc.

**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 doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with 10 CFR 35.75, or from voluntary participation in medical research programs. [10 CFR 20.1003]

**Radiation**

See **Ionizing Radiation**.

**Radiation Area**

An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. [10 CFR 20.1003]

**Radiation Machine**

Any device capable of producing (ionizing) radiation when the associated control devices are operated, but excluding devices which produce radiation only by the use of radioactive material. [17 CCR §30100]

**Radiation Safety Committee (RSC)**

A committee appointed by UCSC administration, and granted authority by the State of California to authorize and control the use of radiation at UCSC.

**Radiation Safety Officer (RSO)**

An individual appointed by the RSC and UCSC administration to manage the Radiation Safety Program at UCSC.

**Radiation Sources**

Any electromagnetic or particulate radiation at levels or amounts that are considered hazardous to the health and safety of university personnel as established by law and other recognized standards approved by the RSC.

**Radiation Use Authorization (RUA)**

An authorization to use radiation, granted by the RSC to a RPI.

**Radioactive Material**

*Radioactive material* means any material which emits radiation spontaneously. [17 CCR §30100]

**Radioisotope**

Any material, solid, liquid, or gas, that emits radiation spontaneously.

**Radionuclide**

See **Radiosotope**

**Rem**

The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 seivert). [10 CFR 20.1004]

**Research and Development**

Theoretical analysis, exploration, experimentation or the extension of investigative findings and scientific or technical theories into practical application for experimental or demonstration purposes, including the experimental production and testing of models, prototype devices, materials and processes; but shall not include human use. [17 CCR §30100]

**Restricted Area**

*Restricted area* means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. [10 CFR 20.1003]

Only occupationally exposed radiation workers are permitted in these areas, unless escorted by radiation safety staff.

**RPI**

The Radiation Principal Investigator is an individual, usually a faculty member or person in charge, who has been authorized by the RSC and granted a Radiation Use Authorization.

**Sealed Source**

Any radioactive material that is encapsulated in such manner that the radioactive material will not be released under the most severe conditions likely to be encountered during normal use.

**Shall**

Indicates a requirement. Compliance is mandatory.

**Should**

Indicates a recommendation. Compliance would significantly enhance safety.

**Source Material**

- (1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or
- (2) Ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material. [17 CCR §30100]

**Special Nuclear Material**

- (1) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Department declares by rule to be special nuclear material after the United States Nuclear Regulatory Commission, 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 foregoing, but does not include source material. [17 CCR §30100]

**State**

Reference to the State means the State of California and any of its agencies empowered to establish regulations regarding radiation and/or radioactive materials.

**Survey**

An evaluation of the radiation hazards related to the production, use, release, disposal, or presence of radiation sources under a specific set of conditions. Often the evaluation includes a physical survey of the radiation source and its surrounding area using monitoring/sample collection techniques suitable for evaluating radiation exposures/doses and/or the quantity of radioactive material present.

**University of California, Santa Cruz (UCSC)**

The term “UCSC” refers to all locations that are under the administrative control of the Chancellor of the Santa Cruz Campus.

**Unrestricted Area**

An area, access to which is neither limited nor controlled by UCSC. [10 CFR 20.1003]

**X-Ray Diffraction and Fluorescence Analysis Machines**

Machines that produce X-ray beams to analyze various substances via X-ray diffraction or X-ray stimulated fluorescence.