

# **Radiation Safety Manual\***

## **Part I**

### Requirements for Radioactive Materials and Machines that Produce Ionizing Radiation



University of California, Riverside  
Environmental Health & Safety

- \* Available from EH&S Radiation Safety and on the UCR EH&S web site [www.ehs.ucr.edu/](http://www.ehs.ucr.edu/).  
Part II, "Requirements for Lasers".  
Part III, "Requirements for Machines that Produce Non-Ionizing Radiation"

## Contact Information

EH&S Web Site .....	<a href="http://www.ehs.ucr.edu">www.ehs.ucr.edu</a>
Radiation Safety Information & Services	
EH&S Radiation Safety .....	Extension 2-5529
Radioactive Waste Pickup	
Integrated Waste Management .....	Extension 2-5518
Emergencies (8:00 a.m. - 5:00 p.m.) .....	Extension 2-5529
Emergencies (after-hours and on weekends)	
Ask For EH&S Radiation Safety .....	Dial 9-1-1 (campus phone)

# RADIATION SAFETY MANUAL

UNIVERSITY OF CALIFORNIA, RIVERSIDE

Prepared as partial fulfillment of requirements for radioactive materials license number 1362-33 and radiation machine facility registration number FAC 10701

## Foreword

This Manual outlines the campus policies and procedures governing the use of ionizing and non-ionizing radiation at UCR. Part I of this manual deals with the use of radioactive materials that are administered under conditions of the UCR Broad Scope Radioactive Materials License and machines producing ionizing radiation that are registered by the State of California. Part II deals with the "Requirements for Lasers" and Part III deals with the "Requirements for Sources that Produce Non-ionizing Radiation".

This document details how relevant local, state, and federal regulations (see Appendix I) are applied at UCR. It was submitted to the State of California Department of Health Services, Radiologic Health Branch as part of the license application, so it's an enforceable part of the radioactive materials license at UCR. This manual supersedes all previous policies and procedures. On occasion, the policies and procedures in this manual will be updated to reflect changes in regulations and "good practice". The current version of this manual is available at the UCR EH&S web site at [www.ehs.ucr.edu/](http://www.ehs.ucr.edu/)

Any proposed uses of radiation that are not compatible with the policies and procedures included in this Manual must be approved by the Radiation Safety Committee prior to implementation.

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Chair, Radiation Safety Committee

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Chancellor

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Radiation Safety Officer

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EH&S Director



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## **1.00 Campus Policy on the Use of Ionizing Radiation**

It is the policy of UCR to implement a Radiation Safety program that maintains the level of exposure to students, faculty, staff and the public "As Low As Reasonably Achievable" (ALARA). The purpose of the radiation safety program is to protect health and minimize the risk to life, property and the environment in the use of ionizing radiation during research, instruction and service.

This Manual assists University personnel in using ionizing radiation in accordance with current standards of good practice, the provisions of the UCR radioactive materials license, and the relevant state and federal regulations. Requests for exemption from procedures in this Manual must be submitted in writing to the Radiation Safety Committee (c/o the Radiation Safety Officer, UCR EH&S).

All individuals responsible for the use of ionizing radiation, the Principal Investigator (PI) as well as administrative and support groups, must have convenient access to a current copy of the Radiation Safety Manual available from EH&S Radiation Safety or on the internet at the UCR EH&S web site [www.ehs.ucr.edu](http://www.ehs.ucr.edu) for use as a reference by persons involved with the project(s) that contain radiation.

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 that produce radiation if such use is immediately dangerous to the life and health of individuals or violates health and safety codes.

## **2.00 Organization and Responsibility**

The radiation safety program will function effectively if each individual or entity involved performs their responsibilities as follows:

### **2.01 Chancellor**

According to the UCR 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. The Chancellor has delegated responsibility for development/ operation of the radiation safety program to the committees, departments, and individuals.

### **2.02 Radiation Safety Committee (RSC)**

The RSC is a body of faculty and other experts appointed by the Chancellor to establish policies and procedures governing the use of ionizing and non-ionizing radiation at UCR to maintain surveillance over activities involving them and to report on the status to the chancellor. Surveillance activities include review/ approval of use applications, review of EH&S Radiation Safety operations, etc. See Appendix II for details.

### **2.03 Office of Environmental Health and Safety (EH&S)**

The Office of Environmental Health and Safety (EH&S) implements the radiation safety program. This program includes surveillance of all users of radioisotopes, 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 III for details.

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

The EH&S Director is an ex-officio member of the RSC responsible for the review of UCR policies on radiation and radiation safety.

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

The RSO is responsible for developing and operating the radiation safety program, for assuring that radiation uses are in conformance with UCR policies and applicable government regulations, and for referring matters to the RSC requiring its review and approval. The RSO is a full voting member of the RSC.

### **2.04 Materiel Manager**

The Materiel Manager is responsible for the acquisition, through established procedures, of all radioactive materials and equipment capable of producing ionizing or non-ionizing radiation. EH&S Radiation Safety will assist Materiel Management as necessary when radiation producing materials or machines are purchased.

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

Deans, Department Chairs, and Administrative Officers are responsible for 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/ government standards and regulations.

### **2.06 Principal Investigator (PI)**

The PI 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 PI is responsible for ensuring that the laboratory environment is safe for use by the Designated User(s) (DU) and in compliance with local, state, and federal regulations, and the conditions of the Radiation Use Authorization (RUA). See Appendix VII for details.

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

The DU is an individual who is listed as a user on a Radiation Use Authorization or who is otherwise using radiation. 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, and for informing the PI and/or RSO of any unsafe conditions known to exist. See Appendix VIII for details.

## **3.00 The Radiation Safety "ALARA" (As Low As Reasonably Achievable) Program**

Federal and State regulations, copies of which are available from EH&S Radiation Safety, regulate the UCR Radiation Safety Program. The program applies to all personnel under University auspices who use, supervise, or control radioactive

materials, machines that produce ionizing radiation (x-ray machines, electron microscopes, accelerators, and neutron generators), lasers, machines that produce non-ionizing radiation, high electric or magnetic fields regardless of intensity or quantity. Exceptions include generally licensed consumer products containing radioactive material (balances, static eliminators, smoke detectors, and chemical reagents containing uranium and thorium) or exempted lasers (pointers). Other than the exceptions noted above, users of "Generally Licensed Materials/ Exempt Quantities", which might ordinarily be acquired without a Nuclear Regulatory Commission (NRC) or State of California specific license, are **not** exempt from the requirements of this manual.

EH&S Radiation Safety must also review the shielding and safety features at facilities where radiation sources are used before the radiation source is initially activated or after changes have been made that may affect safety.

Under normal circumstances, the best interests of UCR research is served by allowing each PI flexibility to establish and implement his own requirements; however, projects involving sources that produce ionizing or non-ionizing radiation have regulatory/ operational requirements that require formal coordination and a degree of external control. Generally, the PI 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.

### **3.01 State Regulation of the use of Ionizing Radiation**

The extent and form of restrictions that apply to each user and facility are determined by Title 17 of the California Code of Regulations (CCR). These regulations are based on NRC 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 binds each person using sources of ionizing radiation (materials and/or machines).

### **3.02 State Licensure of UCR to Use Ionizing Radiation**

Both the laboratory investigator and the State of California Department of Health Services are aware of the difficulties 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 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 UCR. Under the terms of this license, the RSC which is composed of administrators, faculty members, and staff, is granted the authority to approve a wide range of applications, provided it agrees to maintain and enforce the provisions of the State of California Radiation Control Regulations (CCR, Title 17) as specified in the UCR 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 UCR.**

## **4.00 Requirements Related To the Use of Ionizing Radiation at UCR**

When requesting approval to use radiation sources, it is necessary for the applicant to

understand the requirements of the State Regulations, CCR Title 17, as they have been applied at UCR per license conditions. In all cases UCR requirements must meet those specified in the state regulations but in some cases they may be more limiting due to the special conditions prevailing on a university campus. The applicant should know whose responsibility it is to meet these requirements and what assistance may be available to him/her.

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

#### **4.01 Maximum Permissible Exposure**

##### 4.01.1 General Policy:

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

a) For workers with "occupational" exposure:

- Whole body: 5 rem/year
- Lens of eye: 15 rem/year
- Skin of the whole body or extremities (hands and forearms, feet and ankles): 50 rem/year
- Individual organ, other than the lens of eye: 50 rem/year
- Embryo/ fetus of a "declared pregnant woman" (has notified EH&S Radiation Safety, in writing): 0.5 rem during pregnancy

b) For minors (<18 years of age)

- working in areas where radiation is used: 10% of that allowed for workers

c) For workers with "non-occupational" exposure or students under the age of 18 involved in educational activities:

- Long term: 100 mrem/year
- Short term: 2 mrem/hour

As a matter of practice "occupational" exposures at UCR should not exceed 1/10 of the above limits without prior approval by the UCR Radiation Safety Committee.

##### 4.01.2 Pregnant Employees Working With/ Around Radiation Sources:

It is recommended that a pregnant employee:

a) Notify EH&S Radiation Safety, in writing, when pregnancy is suspected.

b) Study information about the effects of radiation on the fetus (available

from EH&S Radiation Safety) and sign a statement indicating that she understands the potential risks.

- c) Maintain radiation exposure to the embryo/ fetus as low as reasonably achievable and in all cases less than 0.5 rems during the full gestation period.
- d) Avoid activities in areas with potentially high radiation exposures such as work with moisture/ density gauges, medical fluoroscopy, portable diagnostic radiography, therapeutic implants, and x-ray diffraction units.

#### **4.02 Controlled Areas**

In areas where, after the incorporation of appropriate safety measures and engineering controls, the use of radiation presents the possibility of exposure to individuals of more than 10 percent of the exposure limits for occupational workers or if the quantity of radioactive materials stored or used in the area is greater than 10x the quantities listed in Table II, the area must be treated as a "Controlled Area". Requirements for controlled areas include: a) Restricting access to the area when it is not occupied by authorized personnel, b) Identifying, with signs, the area(s) involved, c) implementation of personnel monitoring and instrument surveys as appropriate, to determine/document the level of hazard (CCR, Title 17, Sections 30268, 30275, 30276, 30278).

#### **4.03 Training and Instruction of Employees**

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

To satisfy training requirements, the RSC requires that:

- b) All individuals working with ionizing radiation be trained to use it safely prior to the start of work.
- c) That PI's provide, or make available, documented refresher training as follows:
  - Annually for individuals working on projects with a "Hazard Guide Value" (HGV) of III or IV
  - Every two years for projects with a HGV of II
  - Every three years for projects with a HGV of I

In addition, the PI should take every opportunity to improve the technical and professional proficiency of their staff and students, with regard to safety.,

- d) EH&S Radiation Safety provides, general and upon request, specialized training to meet most training requirements.

Additional training from outside sources may be recommended or required when deemed appropriate.

#### **4.04 Internal Deposition Hazards**

Risks that can result from internally deposited radionuclides is a matter of

personal and public concern that can be prevented by implementing containment techniques, minimizing surface contamination, using appropriate personal protective equipment, and using proper engineering controls.

Federal and state regulations place limitations on the allowed levels of contamination for two of the most common routes of human intake, air and water, but do not specify control levels for other possible routes of entry which may be more applicable to laboratory operations. Specific examples include:

- a) Direct contamination of the hands and mouth by laboratory equipment contaminated with radioactive material
- b) Indirect contamination by way of contaminated food, cigarettes, or cosmetics
- c) The possibility of a mishap while mouth pipetting, which should never be done.

Though not specifically mentioned in the regulations, these hazards must also be controlled.

#### **4.05 Environmental Contamination Restrictions**

The RSC reviews each description of radiation use for evidence of appropriate contamination restriction and containment. The levels of contamination permitted in the environment (air and water) are defined. These levels are small and it is required that records be maintained when significant releases occur. Therefore, the user must make suitable arrangements with EH&S Radiation Safety prior to any release (sewer, air), particularly for appropriate waste disposal. (CCR, Title 17, Sections 30285, 30269, 30287)

#### **4.06 Reporting Requirements**

When personnel exposures, environmental releases of radioactive material, or damage to facilities exceed specified values, regulations (CCR, Title 17, sections 30294, 30295 and 30297) require that appropriate regulatory agencies must be notified. Required notifications can be immediate, within 24 hours or within 30 days, depending on the severity of the incident. EH&S Radiation Safety will make any required notifications.

#### **4.07 Licensing of Materials**

All radioactive materials used in the State of California must be licensed/ authorized by the State of California. Under the conditions of a broad scope radioactive materials license, the State of California has granted authority to the University of California, Riverside, Radiation Safety Committee to authorize the use of radioactive materials at any of its facilities.

#### **4.08 Registration of Machines**

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

#### **4.09 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(s) and allowed levels of

contamination in a general setting. Since the educational/ research environment has special scientific and technical needs, it is advisable to address these additional requirements. Specific areas to consider include allowable contamination levels in student areas and areas where low-level counting equipment is used, and minimizing the exposure to personnel and students.

## 5.00 General Operating Procedures

### 5.01 Application for Authorization

Authorization is required before the purchase or use of any source of ionizing radiation, for example:

- a) A sealed source or radiation-producing machine
- b) A new or modified use of radioactive materials
- c) Any new isotope to be used on a previously approved project

#### 5.01.1 Application for Use and Purchase of Radioactive Materials and Radiation Sources

*For an initial application*, complete the forms; "Application for Use and Purchase of Radioactive Materials", Parts I and II. Also submit a "Statement of Training and Experience" for each participant. (See sample Forms in Appendix XIV)

*For subsequent applications*, submit; "Application for Use and Purchase of Radioactive Materials", Part II. Also submit a "Statement of Training and Experience" for each new participant. (See sample Form in Appendix XIV)

Send all completed forms to EH&S Radiation Safety for review and approval.

#### 5.01.2 Application for Amendment

An authorized user who wishes to change a previously approved protocol may not need to reapply with a totally new application. Minor changes (change in location, personnel changes, increase of possession limit by two to five times) can be approved over the phone by the RSO. Other changes can be requested by submitting the "*Application for Amendment*" form. This form is meant to cover such changes as: reactivation of a discontinued project; use of a new isotope for the **same** procedure; an increase of the possession limit for an existing isotope; adding, deleting or changing the personnel working on a project; reporting a change of location; adding additional work areas or other changes which do not alter the original authorization substantially. The amendment must be approved by the RSC following the same procedure as the original application, but it is meant to allow the researcher to effect a minor change with minimal paperwork. Contact EH&S Radiation Safety to determine when the "*Application for Amendment*" is appropriate. (See sample Form in Appendix XIV)

If additional information is required, the RSC may request the applicant to meet with the Committee. Approval is sent in writing and will specify

special conditions related to the use such as: special precautions, special monitoring requirements, modes of disposal, purchase procedures, etc.

## 5.02 Review of Applications

When reviewing applications that request the use of radioactive materials, the Committee considers the following criteria:

### 5.02.1 The Assigned "Hazard Guide Value"(HGV):

The HGV is calculated for each project using the criteria and equation detailed in Appendices IV and V. This process recognizes that some experimental operations are more hazardous than others by reason of engineering controls, materials used, and the chemical reactions involved. If there is uncertainty regarding intermediate steps or end products, the committee may grant conditional approval to proceed with an experiment one step at a time until relevant details can be documented adequately.

### 5.02.2 The 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 as a result of the additional duress presented by potential hazards. Therefore, the proposed project is studied by the Committee to determine that all protective procedures involving radiation hazards are reasonably within the capability of the investigator. The Committee 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.

### 5.02.3 The Adequacy of Facilities:

Adequate facilities can minimize the potential for operational problems. Based in part on the criteria in Appendix IV items to be considered include:

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

### 5.02.4 Familiarity with The UCR Radiation Safety Program:

Evidence will be sought to assure that the PI is familiar with the University Radiation Safety Program, as outlined in this manual, and that he is prepared to institute safety and management controls including:

- a) Inventory records [receipt(s), use(s), transfer(s) and disposal(s)]
- 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) Personnel monitoring and bioassay requirements

### **5.03 Radioisotope Authorization Update**

Each year, usually near the anniversary of the approval, EH&S Radiation Safety will send a form called the "Radiation Use Authorization Update" to each authorized user (See sample form in Appendix XIV). The purpose of this form is to determine the status of the project(s) under a particular authorized user. If a project is to continue, the authorized user must provide all relevant information specified on the status report, and no further action is required. If a project has been completed, a closeout survey will be conducted and the PI's name will be removed from the list of active authorized users.

### **5.04 Purchase and Transfer of Radioactive Materials**

All orders for radioactive materials must be pre-approved by EH&S radiation safety.

#### **5.04.1 Purchase Procedure**

Unless other special arrangements are made with EH&S Radiation Safety, all radioactive materials including "Exempt Quantities" are to be pre-approved by EH&S Radiation Safety (See Appendix IX "Ordering Of Radioactive Materials" for details).

#### **5.04.2 On-Campus Transfers**

All transfers of radioactive material between laboratories must be arranged through EH&S Radiation Safety.

#### **5.04.3 Off-Campus Transfers**

Off-campus transfers can be governed by Federal, State and International regulations depending on the source of destination; therefore, all arrangements for such transfers must be made by EH&S Radiation Safety.

### **5.05 Receipt of Radioactive Materials**

All off site shipments of radioactive materials arrive at EH&S Radiation Safety and are checked for radiation exposure and possible contamination using the procedure in Appendix X, prior to delivery to the PI. Damaged or contaminated packages will be held at EH&S Radiation Safety until the matter is resolved with the vendor/ shipper.

Each user, upon receipt of a package, must log the contents into their "Laboratory Journal". (See Section 6.05)

### **5.06 Inventory Control/ Possession Limit**

The following requirements are established to ensure that users don't exceed the possession limit(s) (by isotope and chemical form) specified in the authorization:

5.06.1

Each new order must be approved by EH&S Radiation Safety, unless other arrangements have been made previously.

5.06.2

The monthly update form (See sample form in Appendix XIV) sent to each authorized PI by EH&S Radiation Safety must be completed and returned **promptly**.

5.06.3

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.

## 5.07 Radiation Exposure and Contamination Control in the Lab

### 5.07.1 Establishing the Level of Radiation Control In The Lab

The level of radiation control required to maintain a safe working environment is based in part on the Hazard Category assigned to the project (see Appendix IV for details). The Hazard Category 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 I ranks selected isotopes according to radiotoxicity. For example: although phosphorus-32 is a high energy beta emitter with a potential for high exposure, it is generally easier to control since it is easy to detect.

### 5.07.2 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 requirements for all situations, but the following can satisfy most needs with slight modifications:

- a) Radiation work and storage areas must be separated from general personnel spaces
- b) Personal belongings, other than those required for work, should not be brought into the laboratory
- c) Eating, drinking, smoking, and application of cosmetics is forbidden in the laboratory
- d) Cover all work areas with absorbent paper as a protection against spills
- e) Provide necessary shielding
- f) Place waste materials in containers as specified in this manual
- g) Maintain good housekeeping throughout the laboratory
- h) Restrict against all possible personal contamination:
  - Restrict public access
  - Use appropriate signs
  - Wear impervious gloves and use tongs
  - Use a remote pipetting technique

- Do not work when open skin wounds can be contaminated
  - Prohibit eating or drinking in radioactive areas
  - Wear laboratory clothing over street clothes and do not wear lab clothing outside of the lab
- i) Clearly mark all contaminated glassware or equipment until it has been decontaminated
  - j) Restrict work with volatile materials to special fume hoods, and work with powders to gloved boxes
  - k) Keep all radioactive materials, other than counting samples, away from counting areas
  - l) Label work areas, materials, and containers as required by the regulations or as a condition of the specific approval
  - m) Learn what instruments are effective for monitoring and how to use them, then monitor any suspect equipment or operation to assure safety. You can't know it is safe unless you have monitored
  - n) If in the course of work contamination is suspected, check with a suitable survey meter or by means of an "area wipe" and decontaminate contaminated areas if necessary. If in doubt, call EH&S Radiation Safety
  - o) Wash hands and check with suitable survey meter before leaving the laboratory

#### 5.07.3 Additional Requirements for High Hazard Procedures

- a) Pre-plan operations in detail:
  - Provide shielding as required
  - Identify actions that will be required in an emergency
  - Develop the skills necessary to satisfy the special needs of the project
- b) Inform personnel working with radioactive materials (and those who could be affected by incidental exposure or accidents) of safety practices and emergency procedures
- c) Personnel monitors are to be worn by all persons participating in a project when they are specified in the approval
- d) Use appropriate laboratory facilities and equipment
- e) Restrict procedures to one radioisotope and one operation at a time wherever possible. Avoid simultaneous and conflicting hazardous situations
- f) Monitor all areas and operations routinely

### 5.08 Personnel Monitoring

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

#### 5.08.1 Requirements:

At UCR, personnel monitoring or bioassay is required when a worker is

likely, during routine operations or in an emergency, to receive radiation exposure from external and internal sources of radiation separately or combined , as follows:

- Whole body: 0.5 rem/year
  - Skin of whole body: 5 rem/year
  - Extremities: 5 rem/year
  - Single organ dose (other than lens of eye): 5 rem/year
  - Lens of eye: 1.5 rem/year
  - Embryo/fetus of a declared pregnant woman: 0.05 rem/9 months
  - Minor (individual <18 years if age):
- a) Whole body monitoring of external radiation exposure is usually by film or TLD monitors/badges that are changed monthly. Monitors that are changed bi-monthly, quarterly or annually are provided to those who choose to be monitored, but who would not otherwise be required to do so.
  - b) Extremity Monitoring is sometimes provided in addition to whole body monitoring when the extremity exposure is likely to be greater than 10 times that of the whole body or it can be used separately to monitor extremity exposure only.. Extremity monitors are usually TLD rings that are changed monthly, bi-monthly or quarterly.
  - c) Internal exposure is usually determined by a bioassay procedure (urinalysis or thyroid uptake) appropriate for the particular isotope and or chemical form(s) being used. Bioassay frequency depends on the work schedule and the material being monitored. Contact EH&S Radiation Safety for details.

#### 5.08.2 External Dosimetry

- a) Typical operations that **require** monitoring:  
Those working directly with radiation producing machines or materials such as:
  - X-ray diffraction units
  - Diagnostic X-ray machines
  - Moisture gauges
  - High energy beta or gamma emitters in quantities greater than 1 mCi
- b) Typical operations where personnel monitoring is **discouraged** due to the limitations of monitoring devices or the low potential risk:
  - Electron microscopy
  - Work with gas chromatograph sources that contain <sup>3</sup>H or <sup>63</sup>Ni
  - Work with low energy beta emitters such as <sup>14</sup>C, <sup>35</sup>S, <sup>3</sup>H, or <sup>45</sup>Ca
  - Work where the exposure is likely to be less than 10 mrem/ month
- c) Availability/ Distribution of personnel monitors (whole body or extremity):

- 1) Personnel monitors are supplied by EH&S Radiation Safety. Requests for monitors are directed to EH&S Radiation Safety, usually by the laboratory supervisor.
  - 2) A request for personnel monitoring must include the following information:
    - Name of user
    - Social Security Number
    - Date of birth
    - Name of PI for lab
    - Type of radiation exposure (X-ray diffraction, 32P, Moisture probe, etc)
  - 3) Monitors will be delivered to the lab supervisor or a designated individual who will distribute them to the actual user(s).
  - 4) Monitors will be changed monthly, bi-monthly or quarterly as specified in section 5.08.1 above or when an accidental exposure in excess of regulatory limits is suspected.
- d) 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 chest, 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 (moisture, or heat)
  - 5) Exchange monitors promptly when replacements arrive
  - 6) Use only a monitor that is issued to you

### 5.08.3 Bioassays

A Bioassay is performed to determine the amount of radioactive material (activity) present in the body. Once the amount of material present is determined, the resulting radiation exposure can be calculated. Bioassays are performed when specified as a condition of an authorization or when there are suspicions an uptake is exceeding a regulatory limit.

- a) Typical requirements:
- 1) For tritium used in a non-contained form, the Bioassay frequency is as follows:
    - 10 mCi to <100 mCi used quarterly or <10 mCi in one vial recommended quarterly bioassay

- 100 mCi to <8 Ci in one vial require bioassay within one week
  - 8 Ci or more in one vial require bioassay within 24 hrs
- 2) For  $^{123}\text{I}$ ,  $^{125}\text{I}$ ,  $^{131}\text{I}$  as sodium iodide with pH 7, the Bioassay frequency is as follows:
- 1 mCi to <10 mCi used quarterly or 1 mCi in one vial recommended quarterly bioassay
  - 10 mCi to <100 mCi used quarterly or 10 mCi in one vial require quarterly bioassay
  - 10 mCi to <1 Ci in one vial require bioassay within 2 weeks for  $^{125}\text{I}$ , within 1 week for  $^{131}\text{I}$ , or within 24 hours for  $^{123}\text{I}$
  - 1 Ci or greater in one vial require bioassay within 24 hours
- 3) For  $^{123}\text{I}$ ,  $^{125}\text{I}$ ,  $^{131}\text{I}$  as sodium iodide with pH <7 bioassays as follows:
- 10 mCi to <100 mCi used quarterly or >10 mCi in one vial recommended quarterly bioassay
  - 100 mCi to <1 mCi used quarterly, or <100 mCi in one vial require quarterly bioassay
  - 100 mCi to <10 mCi used in one vial require quarterly bioassay within 2 weeks for  $^{125}\text{I}$ , within 1 week for  $^{131}\text{I}$ , or within 24 hours for  $^{123}\text{I}$
  - 10 mCi or more used in one vial require bioassay within 24 hours
- 4) Before a bioassay can be completed the individual must provide the following information:
- Name
  - Social Security Number
  - Date of birth
  - Name of PI for the lab
  - Type of radioactive material uptake (isotope and chemical form in use)
- Date and time when procedure was performed
- 5) Specific information about the particular bioassay being performed will be provided to the individual at the time of the bioassay

#### 5.08.4 Pocket Dosimeters

Pocket dosimeters can be used to monitor radiation exposure:

- a) Whenever a person attempts a new procedure where the radiation exposure to personnel has not been established (to establish a procedure that will minimize personnel exposure)
- b) Whenever a person engages in a procedure involving radiation exposure levels that could potentially cause an over-exposure
- c) Except for visitors, any person required to wear a pocket dosimeter must also wear a film badge. If use of a pocket dosimeter is required as a condition of the approval, it must be calibrated appropriately

(contact EH&S Radiation Safety for details) and its reading must be recorded in the "laboratory journal" along with the date of the readings and the specific use of the dosimeter

5.08.5 Distribution of monitoring results and notifications:

Exposures measured by personnel monitors and determined from bioassays are reviewed by EH&S Radiation Safety and distributed to the laboratory supervisor in each department where individuals are monitored. The laboratory supervisor must make them available to the individuals being monitored. The worker can request a summary report of exposures received while working at UCR.

5.08.6 Review/ Investigation of Radiation Exposures:

All exposure results will be reviewed by EH&S Radiation Safety. Exposures >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 identify how future exposures can be reduced.

**5.09 Laboratory Inspections, Instrument Surveys and Area Wipes**

While the majority of UCR programs for radiation control rely on correct experimental design, the problem of contamination is most easily handled when the authorized user performs appropriate instrument surveys or area wipes routinely.

As a general policy, the RSC requires all users of radiation to equip themselves with instruments suitable for their own monitoring needs.

Laboratories will be monitored/ surveyed by the user at the following frequencies based on the assigned Hazard Category (see Appendix IV):

Hazard Category	Survey Frequency
I	Monthly*
II	Weekly*
III	Daily
IV	Daily or continuous as required

\* If work with radioactive materials is occasional, a survey must be performed after each use or quarterly, whichever is more frequent.

In some situations, the detection of significant radioactivity where its presence has not been foreseen should bring immediate action to control it and to prevent a recurrence. In other situations, the radiation in a given area may be present because there is no reasonable way of avoiding it. In such cases, survey measurements are needed to determine the level of possible internal and external exposure hazard. Repeated surveys may be necessary where an experiment produces variable levels of radiation exposure/ contamination. (See Appendix VI for Area Survey and Monitoring Procedure.)

**5.10 Posting Requirements**

A variety of notifications and instructions as well as warning signs and labels bearing the radiation symbol and the appropriate officially prescribed notation (Radioactive Material, Radiation Area, High Radiation Area) are available. While the correct usage of each is described in the CCR, Title 17, Section 30278, some

confusion occasionally arises where posting is required by law under conditions where the hazard to laboratory staff appears to be insignificant. In order to clarify any confusion, the following is required:

- a) Notices/ instructions must be posted in each radiation work area: "Notice to Employees", Routine Laboratory Procedures, Emergency Laboratory Procedures and equipment operating procedures as appropriate.
- b) Warning signs and labels must be used to identify radiation sources and areas where radiation is used:
  - All radioactive materials, except counting samples (planchets and vials) and the area(s) in which they are encountered must be identified with appropriate signs or labels for the benefit of non-technical personnel (maintenance, building services, emergency response personnel, secretaries, and visitors) who may, however infrequently, have business in the laboratory during the absence of the authorized user.
  - Areas and access doors to rooms where specified quantities of radioactive materials are stored or used (see below for details) must be labeled as "Radioactive Materials".
  - Containers containing radioactive materials must be labeled as "Radioactive Materials", but must also include the following information: radioisotope, activity and date.
  - Areas with and the access doors to areas with specified exposure rates (see below for details) must be labeled "Radiation Area" or "High Radiation Area" as appropriate.

#### 5.10.1 Use of Signs and Labels

- a) Isotopic Solutions, Radiochemicals in Storage, and Radioactive Waste

Each vial or container must be labeled as "Radioactive Material" with the following information: radioisotope, activity and date.

Where double containers are used, both inner and outer container(s) require labeling unless the inner label is visible from the outside. Proper labeling requirements also apply to radioactive waste.

- b) Laboratories

A "Radioactive Material" sign must be posted at each access door to a laboratory where radioactive materials are stored or used in quantities greater than 10x the limits stated in Table II. If several isotopes are present, the access doors must be posted when the sum of the ratios of the activities present divided by the activities from Table II is greater than 10.

Where:

$A_i$  = Activity Present

$A_{ti}$  = Activity from Table II

A "Radiation Area" sign must be posted at each access to a room where the exposure to working personnel (exposure measured at 12

inches from a radiation source) exceeds 5 mrem/hour.

A "High Radiation Area" sign must be posted at each access to a room where the exposure to working personnel (exposure measured at 12 inches from a radiation source) exceeds 100 mrem/hour.

c) Laboratory Equipment and Containers

Labeling requirements depend on the relative permanency of the radiation operation. Any apparatus that will contain significant radioactivity for eight hours or overnight due to prolonged experimentation or contamination, must be individually labeled as "Radioactive Materials" with the following additional information: isotope, activity, and date. Where usage is only temporary, no individual labels are required, but a "Radioactive Material" warning sign must be placed so that it clearly indicates the presence and location of radioactive materials. This requirement is most easily accomplished when radiation use is confined to a single area of the laboratory.

d) Laboratory Work Areas

Work areas can be identified by covering them with absorbent paper and securing the edges with "Radioactive Material" tape. This practice not only identifies the work area, but protects the work surface as well.

e) Sealed Radiation Sources and Radiation Producing Machines

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

The area where a radiation source is stored or used will require the posting of "Equipment Operating Instructions" and a "Radiation Area" warning sign if the measured exposure at 12 inches from the source exceeds 5 mrem/hour, or a "High Radiation Area" sign if radiation levels exceed 100 mrem/hour at 12 inches from the source.

f) Waste Containers

Each waste container must have a "Radioactive Material" label and prior to pickup by EH&S Radiation Safety, a "Request For Radioactive Material Pickup" label. Waste containers should be covered when not in use.

5.10.2 Posting Requirements for Radiation Laboratories/ Work Areas

- a) "Radiation Area" - Rooms where exposure to working personnel (exposure measured at 12 inches from a source of radiation) exceeds 5 mrem/hour will require "Radiation Area" posting.
- b) "Notice to Employees" - (Form #RH-2364) 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 the CCR, Sect. 30280.

- c) "General Operating Procedures"
- d) "Equipment Operating Procedures" if appropriate
- e) "Emergency Procedures and Phone Numbers"
- f) "Personnel dosimetry reports" if any (recommended, but not required)

## 5.11 Decontamination Procedure

During the course of work and in spite of precautions, laboratory surfaces, equipment, clothing, etc., may become contaminated. Such contamination does not necessarily present a serious hazard, provided it is detected promptly and not allowed to spread or be ingested. Emergency plans for several types of emergencies are given in Section 8.00 of this document. In most cases, a surface or material may be cleaned using ordinary methods (soap, water, brush). When these simple decontamination methods fail (because the surface or material is porous or because of the level of contamination is very high) more aggressive methods must be used. In cases when it is not feasible to remove all contamination, the levels of contamination listed in Section 5.11.2 are considered to be safe for small areas or spots of contamination. If these levels can't be obtained, or if the contamination is extensive, call EH&S Radiation Safety for assistance.

5.11.1 During a Decontamination Procedure it is Important to:

- a) Wear appropriate protective clothing (gloves, lab coats, shoe covers, etc.)
- b) Confine the spread of contamination
- c) Carefully remove all loose or easily removable contamination, followed by washing with soap, detergent, or special solvents (work from low to high contamination areas)
- d) Place all cleaning materials (absorbent materials, gloves, etc.) in a radioactive waste container

5.11.2 Tolerable Decontamination Levels

Radioactive contamination should be maintained as low as reasonably achievable, and must not exceed the levels specified in Table III unless a special authorization is granted by the RSC. Compliance with these levels can be determined by the use of an appropriate survey meter or area wipe.

a) Area Wipe or Smear

This is a method used to determine the amount of radioactive contamination that can be removed from a surface by rubbing with a wipe or smear. In most cases, wipes should be taken with a piece of absorbent material (filter paper) dry or moistened with an appropriate solvent, from an area not less than 100 cm<sup>2</sup> for large objects; for small objects, wipe as much of the total surface area as possible. Specific areas to check are cracks and corners in floors and counter tops, the area around container closures, and the inside of shipping containers. This method of contamination detection is particularly useful since it is an effective way to monitor for low energy radiations (C-14, H-3), or in

areas that are hard to monitor by other methods (high background). Once a wipe is taken, the removable contamination can be measured using any appropriate detection system, usually the regular sample counting equipment in the laboratory (liquid scintillation, gamma counter, GM detector, etc.) is adequate when appropriate counting techniques are used. The allowable amount of removable contamination, as determined by a wipe, depends on factors such as the type of radiation present and where it is found. (See Table III)

## 5.12 Radioactive Waste Management

The radioactive waste management program is designed to protect the individuals dealing with waste and the environment.

### 5.12.1 General Considerations:

- a) Releases to the environment (sewer, air, & ordinary trash) must be as low as reasonably achievable and not exceed regulatory limits
- b) When disposing of radioactive waste, recognize that other hazards can be present (biohazards, chemicals, sharps, etc.) and that each must be treated appropriately
- c) If a hazard can be eliminated legally at the point of generation it should be (sterilization of biohazards)
- d) Segregate wastes according to the processing and/or disposal method (liquids from solids, long from short half life, etc.)
- e) Avoid personnel exposure and/or area contamination by:
  - Shielding waste containers as required
  - Providing secondary containment for liquids
  - Minimizing the quantity of waste stored in labs

### 5.12.2 Radioactive Waste Disposal Procedure

The following Radioactive Waste Disposal Procedure has been developed based on the considerations above.

- a) Radioactive waste must **not** be placed in any ordinary trash receptacle or vice/ versa.
- b) Reduce volume whenever possible. After monitoring, discard any uncontaminated material (packing material) in the ordinary trash or according to its other hazards as appropriate.
- c) Remove or completely deface all radioactive material labels from non-radioactive materials/ packages placed in the ordinary trash receptacle.
- d) Do not mix other hazardous materials/ waste with radioactive waste (no lead "pigs").
- e) Eliminate other hazards when permissible (sterilization of biohazards). Contact EH&S Radiation Safety for assistance (ext. 2-5529).

- f) Limit sewer disposals to washings, but in no case exceed 50 uCi per month.
- g) Use only waste containers provided or approved by EH&S that are compatible with the material being collected. Fill containers only to 80% of capacity.
- h) Liquids other than those containing iodine must be maintained at a pH between 5 and 9. Liquids containing iodine must be maintained at a pH between 7 and 9.
- i) Provide secondary containment for all liquid waste containers except for tightly lidded liquid scintillation vials stored in trays.
- j) Segregate the waste generated by the various procedures unless they are known to be similar physically, compatible chemically and radiologically. See the Radioactive Waste Segregation Guidelines (Appendix XIII) for details. Call EH&S Radiation Safety if there are questions.
- k) Label all waste containers appropriately:
  - 1) Before adding waste:
 

With a "Radioactive Material" label and when feasible identify:

    - Name, location, and phone number of lab.
    - The general type of waste (scintillation cocktails, dry solid, etc.).
    - Isotope(s) present.
    - Hazardous materials present (e.g., organics, corrosives, toxics, etc.).
  - 2) Before pickup by EH&S:
 

Complete the "Request For Radioactive Material Pickup" form. Required information includes:

    - Activity of each isotope present at the time of pickup.
    - Quantity (g, Kg, ml, etc.) or percent of each chemical present.
    - Date of request.
    - Name of individual completing the form.
- l) For pickup of waste, Call EH&S Radiation Safety, ext. 2-5529

### 5.13 Health Physics Audits and Inspections

The frequency of health physics audits is based on the hazard category assigned to an authorization as follows (See Appendices IV and V for details):

Hazard Category	Health Physics Survey Schedule	
	Subcategory A	Subcategory B
I	Semi-annual	Annual
II	Quarterly	Semi-annual
III	Monthly	Quarterly

IV

Weekly

Monthly

Subcategory A frequencies are assigned to new RUA's. Subcategory B frequencies are assigned when the health physicist is satisfied that a project is well established.

Annual audits will usually be on or about the anniversary of the original approval date, and are intended to determine if operations are being conducted properly/ safely.

Audits check that:

- Records are maintained and current
- Lab procedures are available and followed
- Signs, labels and notifications are used/ posted as required
- Radiation uses are in accordance with the conditions of the RUA
- Contamination surveys are conducted and recorded as required
- Personnel working with radioactive materials are approved
- Contamination/ exposure levels in the work area
- Survey meter calibration

If contamination or high radiation areas are found, or if other problems are identified, it will be the duty of the PI to take corrective action promptly.

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

If the evaluation by the RSO indicates recurring or chronic problems, continued authorization by the RSC may be contingent upon a more extensive monitoring program and additional personnel training by the PI. Assistance may be obtained from EH&S Radiation Safety. (See Appendix VII for details.)

#### **5.14 Decommissioning of Facilities and Equipment**

Once radioactive materials or radiation producing machines are used in an area, there is the possibility that surfaces or equipment will be contaminated or activated. EH&S Radiation Safety must survey areas and equipment and if necessary, decontaminated to the levels specified in Section 5.11 of this manual before they can be released for unrestricted use. If decontamination efforts are unsuccessful, demolition or disposal of contaminated material/ equipment may be required. Decontamination is the responsibility of the PI, but EH&S Radiation Safety will provide technical assistance and supervision if necessary.

### **6.00 Required Records**

#### **6.01 Application, Amendment, and Authorization**

Copies of the original application and authorization must be kept on file by the user for reference to the specific requirements and conditions of use.

#### **6.02 Purchase Requests**

The authorized user must retain one copy of each requisition or purchase order that requests a radiation source.

### **6.03 Radioisotope Status Report**

A copy of the Radioisotope Status Report will be sent to each PI at yearly intervals. The form must be completed and sent to EH&S Radiation Safety (a copy should be retained by the user). The information contained on this form will enable the RSC to know the status of each project. It is important to return this form promptly to remain on the list of authorized users.

### **6.04 Dosimetry Reports**

Laboratories that require personnel dosimetry will receive a monitoring report from EH&S Radiation Safety that lists the exposure from external sources and internally deposited radioisotopes as appropriate. These reports must be made available to all participating lab personnel.

### **6.05 Laboratory Journal**

Each user must maintain records in a journal notebook (3-ring binder). The journal is a necessary part of the records required by State regulations. It must be available for review by EH&S Radiation Safety and State Inspectors. It must contain the following information:

- a) Each receipt of a radioisotope (isotope, chemical, or physical form, quantity and date of receipt).
- b) Each withdrawal of stock from the supply bottle including date, amount, and use.
- c) Results of required radiation surveys for contamination and exposure rates (instrument surveys and wipe tests). Entries must include the date, person making the survey, the instrument or method used, locations and levels of activity/ exposure encountered (all values are important, so record all measured values, even zero or background levels). When high readings are found, make corrections and record the new reading next to the initial reading. When the cause of a high reading is known, it should be identified.
- d) Documentation of training provided in the laboratory to lab personnel.  
Additional miscellaneous entries in the Lab Journal can include the addition or deletion of personnel from the project staff, and a record of personnel dosimetry.
- e) Give a complete history of and corrective action taken for any incident/ accident that involves a "Major Spill" or the release of a gas, powder, or volatile material as defined in Section 8.00.
- f) Each disposal of radioactive waste.
- g) Data necessary to demonstrate compliance with any special requirements placed on the specific authorization.

## **7.00 Available Resources**

### **7.01 "Hot" Laboratory Facilities**

Student and faculty research laboratories may not be equipped or designed adequately to satisfy radiation control requirements if millicurie quantities of radioactive materials are routinely used. In cases when facilities are not

adequate, modification or special facilities may be required. If the projected research is of reasonably short duration, it may be possible to arrange with EH&S Radiation Safety for temporary use of other facilities rather than to attempt modification of a departmental laboratory. In some cases, approval of an application may be contingent upon such an arrangement.

## **7.02 Safety Consultation and Training**

PI's are responsible for increasing the capability and knowledge of their staff and students by an ongoing and documented instructional program. In some cases, a simple tutoring arrangement will satisfy this requirement. In other cases, the complexity of the physical and biological issues presented by the particular radiation problem must be addressed in depth. Knowledge of exposure levels associated with the work and methods that can be employed to minimize them is essential. Furthermore, each person in the laboratory should be able to deal with emergencies involving the radiation being used. To function effectively in routine and emergency situations, users need a thorough familiarity with the physical and biological properties of the experimental materials, procedures involved and the basic principles of radiation safety.

Since a comprehensive program of instruction in radiation control and health physics may involve special information beyond the direct area of interest of the investigator, the RSO has resource materials available or can direct the PI to sources that may be useful. The RSO can arrange for special courses or labo demonstrations and lectures upon request. It must be emphasized, however, that abbreviated training courses of this sort are most effective when the lab supervisor guides the course and provides motivation for continued interest. To satisfy basic training requirements, general initial and refresher training courses are offered routinely by EH&S Radiation Safety, but the specific training required to perform specialized procedures must be provided by the PI. Please call EH&S Radiation Safety or see the EH&S web site for information regarding the availability of training courses.

## **7.03 Personnel Monitoring**

Monitoring personnel for exposure to radiation is addressed in a variety of ways intended to serve the needs of the individual user. In many cases, approval to use radioactive materials or machines is contingent upon implementation of an appropriate personnel-monitoring program as specified in Section 5.08. Contact EH&S Radiation Safety for details.

## **7.04 Instrument Use and Calibration**

Portable survey instruments such as Geiger counters, scintillation counters, and ionization chambers or any instrument used to monitor a lab for contamination or measure radiation exposure, require periodic calibration. EH&S Radiation Safety and a campus electronics shop are equipped to calibrate most portable instruments electronically or in radiation fields using sources/methods traceable to the National Institute of Standards and Technology. Instrument calibrations can be corrected for energy dependent response when requested.

Training on how to use a survey instrument is available from EH&S Radiation Safety.

## **7.05 Contamination Surveys, Area Monitoring, Leak Testing**

EH&S Radiation Safety can perform or assist with radioactive contamination surveys/analyses, radiation exposure monitoring, and analysis of unknowns when situations require resources beyond those available in the student or research laboratory (spill, release, etc.).

## **7.06 Waste Disposal**

EH&S manages all radioactive waste disposals to most efficiently address the regulatory and record keeping requirements associated with radioactive waste and the special needs of waste generators. Never place a container with a "Radioactive Material" label or radioactive waste in the ordinary trash or sanitary sewer.

## **7.07 Materials Available from EH&S Radiation Safety**

### 7.07.1 Forms (See sample forms in Appendix XIV)

- a) General Application for Use and Purchase of Radioisotopes and Radiation Sources, Part I
- b) General Application for Use and Purchase of Radioisotopes and Radiation Sources, Part II
- c) Application for Amendment
- d) Statement of Training and Experience, General
- e) Authorization for Radioisotope Use
- f) Radioisotope Authorization Update Form
- g) Application to Use Machines that Produce Ionizing Radiation
- h) Film Badge Request
- i) Authorization to Release Radiation Exposure Records
- j) Pregnancy Report
- k) Radioisotope Withdrawal Log

### 7.07.2 Instructions and Signs

- a) General laboratory instructions
- b) Emergency procedures
- c) Notice to Employees # RH2364
- d) Appropriate warning signs

### 7.07.3 Information

- a) Radiation Safety Manual  
Part I, Requirements for Radioactive Materials and Machines That Produce Ionizing Radiation  
Part II, Requirements for Lasers  
Part III, Requirements for Machines That Produce Non-Ionizing Radiation
- b) Radiation Worker's Guide
- c) Personnel monitoring reports
- d) Reference Materials: NCRP, ICRP, and others

## 7.08 Services Available From EH&S Radiation Safety

- a) Registration of radiation producing machines
- b) Radiation Use Authorizations
- c) Approval of orders for radioactive materials
- d) Instrument calibration
- e) Reference materials
- f) Consultation:
  - Laboratory design
  - Laboratory techniques/procedures
  - Shielding design
  - Instrument selection
- g) Training in radiation protection techniques
- h) Waste disposal:
  - Contract
  - Decay
- i) Emergency equipment

## 8.00 Emergency Response Plans

Any spill or release of radioactive material must be controlled promptly. The responsibility for cleaning or calling for experienced help rests on the individual(s) working in the area involved and the authorized user. Instructions for controlling and decontaminating minor spills and safe levels of contamination are specified in Section 5.11.

Under no circumstances should an untrained person attempt to evaluate or clean a significant spill (An uncontrolled or inadvertent release of radioactive material that exceeds the amount specified in Table II) of radioactive material. 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. Ordinarily, fans or ventilating apparatus should **not** be turned on in an attempt to blow airborne radioactive materials or their decay products away. Such action may spread radioactive material throughout the area. If airborne contamination escapes from a building, wind currents may carry the materials into nearby windows or air intake ducts. The impact on people, environmental pollution, facilities operation and financial losses are minimized when proper precautions are taken immediately after a spill occurs.

The RSO must 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 a contaminated area
- The loss of radioactive materials, sealed source(s) or radiation producing machine(s)

### 8.01 Release Involving Gas, Volatile Liquid, Dust, or a Sealed Source Rupture

If a sealed source ruptures, or if potentially hazardous quantities of radioactive dusts, mists, fume, organic vapors or gases are introduced into the air, the following emergency measures must be taken immediately:

- a) No **immediate** attempt should be made to clean the spill.
- b) All windows should be closed, fans and air conditioners should be shut off or vents sealed, and everyone should leave the room.
- c) All doors should be closed, locked, and a warning sign placed at each access door.
- d) If powdered or gaseous sources are involved, the door and all other openings leading into the room should be sealed with wide tape (masking tape, duct tape, adhesive tape) and plastic sheeting or heavy wrapping paper.
- e) Minimize the spread of radioactive contamination by restricting the movements of potentially contaminated persons to a local zone just outside the "spill" area until the extent of personnel, shoe and clothing contamination is determined.
- f) Every person who might have been contaminated should be monitored for activity, and, if contaminated, should remove his/ her clothing and be decontaminated. If no means are available for monitoring, it should be assumed that the person is contaminated.
- g) The RSO must be called **immediately**. If necessary, outside consultants experienced in radiation hazards should be called in by the RSO and their advice followed.

### 8.02 Radioactive Liquid Spill

The following procedures will be followed, unless the radioactive liquid is volatile, in which case, use the procedure for "Gas, Volatile Liquid, Dust, or a Sealed Source Rupture".

#### 8.02.1 Minor Spills (less than 0.1 mCi for Iodine, or 1.0 mCi for other radionuclides)

- a) Notify all persons in the room immediately
- b) Permit only the minimum number of persons in the area necessary to deal with the spill
- c) Put on personal protective equipment as necessary
- d) Confine the spill immediately. Cover with absorbent paper
- e) Decontaminate, using a monitor to check the progress of the work (See Table III)
- f) Monitor all persons involved in the decontamination process

8.02.2 Major Spills (greater than 0.1 mCi for Iodine, or 1.0 mCi for other radionuclides)

- a) Tell all persons not involved in the spill to vacate the room at once, and notify the RSO
- b) When feasible, use reasonable effort to confine contamination
- c) If the spill is on clothing, discard outer clothing at once
- d) Vacate the room
- e) Take immediate steps to decontaminate all personnel involved

**8.03 Inert Gas Release (Xe-133)**

For quantities >50 mCi:

- a) All persons leave the room to an area just outside the contaminated area
- b) Insulate the contaminated area by closing and securing all doors entering the contaminated area
- c) Activate exhaust systems if present
- d) Call the supervisor and EH&S Radiation Safety for assistance, ext. 2-5529
- e) Do not re-enter the contaminated area until checked by the supervisor and EH&S Radiation Safety

**8.04 Multiple Emergencies**

When a radiation emergency is accompanied by other hazards (fire, explosion, chemical exposure, or other event that endangers life 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 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.

**9.00 Requirements for Machines That Produce Ionizing Radiation (X-Rays)**

The following requirements apply to machines that produce ionizing radiation (radiation producing machines such as x-ray diffraction units, electron microscopes, medical x-ray machines, and cabinet radiography units) and supplements the general information contained in the previous section of the Radiation Safety Manual that deals with radioactive materials.

**9.01 General Requirements**

9.01.1 Acquisition, Modification, Transfer, Disposal of Radiation Producing Machines

Notify EH&S Radiation Safety prior to acquisition, modification, transfer or decommissioning of an operational radiation producing machine.

- a) Submit an "Application for Use of Machines That Produce Ionizing Radiation" to EH&S Radiation Safety that includes the following

information:

- Responsible/ contact person
- Evidence that all individuals involved have training and experience that is adequate for the proposed project
- A description of the machine (type of machine, manufacturer, model, year of manufacture, maximum and usual energy, and beam current)
- A description of the facility and any required safety interlocks/ devices

**NOTE:** For machines that are manufactured commercially and equipped with engineering controls that will effectively contain the radiation that is produced, provide a copy of the manufacturers specifications and drawings for review.

- Operating procedure
- A sample "Use Log", if required (see section 9.01.9)
- Radiation survey/ monitoring procedure, if required (see section 9.01.6b)

#### 9.01.2 Facility/ Equipment Review/ Inspections

Plans for facilities that include radiation producing machines must be reviewed before they are put into operation and periodically thereafter to assure that they are initially and remain safe, in compliance with appropriate Federal, State, and Local regulations.

##### a) Initial Review:

Prior to operation of a new/ modified radiation producing machine or facility, the machine or facility must be inspected/ surveyed by EH&S Radiation Safety. The inspection/ survey is intended to determine if the machine/ facility is safe for the intended use and that it is in compliance with appropriate Federal, State, and Local regulations.

##### b) Periodic Inspections:

EH&S Radiation Safety will inspect facilities that include radiation producing machines to assure that they are in safe operating condition and in compliance with appropriate Federal, State, and Local regulations/ requirements.

#### 9.01.3 Registration

EH&S Radiation Safety must register all radiation producing machines with the State of California, Radiologic Health Branch within 30 days after initial operation, and as required thereafter. This requirement can be met only if EH&S Radiation Safety is notified immediately when a new machine is acquired.

#### 9.01.4 Annual Authorization Update

Each year the individual who is responsible for a radiation producing machine must submit an Annual Update report to EH&S Radiation Safety. The report will include the following information:

- a) Facility changes desired
- b) User changes
- c) Use or protocol changes

#### 9.01.5 Maximum Allowed Exposures

Radiation producing machines must be used according to the instructions provided by the manufacturer and recommendations by EH&S Radiation Safety. In all cases machines must be used such that the radiation exposure to operators and individuals in surrounding areas is as low as reasonably achievable and does not exceed the limits specified in the UCR Radiation Safety Manual.

#### 9.01.6 Radiation Monitoring

To assure that radiation exposures are as low as reasonably achievable and that maximum limits are not exceeded (see section 3.0) personnel monitoring and area surveys are necessary as follows:

##### a) Personnel Monitoring:

Radiation monitors must be worn by all individuals working in areas where the potential for exposure to radiation meets the criteria specified in this manual. Typically, personnel monitors should be worn by any individual working with radiation producing machines. 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.

##### b) Area Surveys:

Radiation area surveys must be performed prior to initial operation, following modifications, and periodically thereafter. Appropriate survey methods and frequencies will be determined by EH&S Radiation Safety during the initial review and reevaluated periodically during the routine reviews/surveys/inspections conducted thereafter. The determination of methods and frequencies is based on generally accepted practices and the specific conditions that exist at the machine/ facility. Required surveys will be performed by the user or EH&S Radiation Safety as negotiated between the authorized user and EH&S Radiation Safety during the initial and periodic project reviews.

#### 9.01.7 Personal Protective Equipment (PPE)

In general, personal protective equipment (leaded aprons, gloves, and 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 whenever the exposure can be reduced significantly by their use, but not in place of other required engineering controls. Other than the voluntary use of PPE, all uses must be approved by EH&S Radiation Safety.

9.01.8 Safety Devices/ Features (shielding, interlocks, safety/ warning lights/ alarms)

Federal, State and local regulations require that many radiation producing machines have specified safety devices or features. In addition, EH&S Radiation Safety may specify safety features to address the specific use of the machine at UCR. Required safety devices/ features include:

- a) Fail safe warning lights
- b) Fail safe interlocks
- c) Beam enclosures
- d) Shielding/ shielding interlocks
- e) Radiation survey meters
- f) Radiation area monitors
- g) Viewing windows

All required safety devices must be maintained in working order, and must 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 must be developed that provides the same degree of protection as the original. Modified safety devices/ methods must be approved by EH&S Radiation Safety prior to operation of 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 must **not** be operated until it is repaired and subsequently checked by EH&S Radiation Safety. EH&S Radiation Safety must be notified immediately if an unexpected personnel radiation exposure occurs or is suspected.

9.01.9 Operating Procedures

Operating procedures must be approved by EH&S Radiation Safety and be made available in the immediate work area to all users of the radiation producing machine(s).

9.01.10 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 determining the operating status/ reliability of a machine. Therefore, a "Use Log" is most important for machines that have the highest potential for exposure (X-ray diffraction units with open beams, and field radiography units).

Based on the above considerations, a "Use Log" **should** be maintained for all radiation producing machines but **must** be maintained for all radiation producing machines with open beams or those that are not equipped with fail-safe engineering controls (interlocked shields) that will effectively contain the radiation.

Information to include in a "Use Log":

- Name of user
- Description of use
- Date of use
- Malfunctions/ problems noted, and corrective actions taken
- A record of routine service/ maintenance

#### 9.01.11 Posting (signs, notices, and instructions)

Radiation producing machines and surrounding areas must be identified/ posted with signs, notices, and instructions in accordance with the requirements in 17, CCR, Section 30278.

Posting requirements include:

- a) Notice to Employees
- b) Operating/ safety instructions
- c) Warning signs as appropriate

#### 9.01.12 Training

All users of radiation producing machines must have documented training that is adequate for the work being performed.

Training must include the following topics:

- a) A description of ionizing radiation
- b) Radiation effects
- c) Radiation exposure limits
- d) Potential exposures related to the work being done
- e) Methods to reduce exposure
- f) fSpecial radiation monitoring methods/ techniques, if required
- g) A description of pertinent Federal, State, and local regulations
- h) An introduction to the radiation safety program at UCR (see "UCR Radiation Workers Guide")
- i) Required notices, signs, warnings, and labels
- j) Operating procedures for the equipment being used
- k) Reporting and dealing with high/ over exposures

#### 9.01.13 Machine Location

As a general safety precaution, and to allow 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/ limited by other means, primary beams must be intercepted by a primary barrier and limited such that personnel cannot be irradiated by them. Scatter/ secondary radiation must 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.

## 9.02 Summary of Requirements for Specific Machine Categories

The following summaries are general, so may not apply in all circumstances. If modifications are desired, call EH&S Radiation Safety for review/ approval prior to implementation.

### 9.02.1 X-ray Diffraction

Open beam x-ray diffraction units can be hazardous because of the high exposure rates (several 100,000 R/minute) at the x-ray port. Serious injury can result if any body part is exposed to this high radiation exposure rate, even for a very short time. Furthermore, x-ray beams are often small and difficult to find and measure. Therefore, extreme caution must be exercised when working with x-ray diffraction equipment.

Requirements for The Safe Use of X-Ray Diffraction Units:

- a) All individuals using a unit must have documented training to use the specific equipment
- b) Follow approved, written operating procedures
- c) If required, establish a "Use Log" that is available for review
- d) Using an appropriate survey instrument, monitor radiation exposures at the time of initial operation and when modifications are made
- e) Wear appropriate radiation monitoring devices
- f) Required/ appropriate warning lights and other safety devices must be in place and operational
- g) Required/ appropriate radiation shielding must be installed on each x-ray diffraction unit. Required shields should be interlocked to prevent radiation exposure to personnel if the shield is removed or displaced
- h) All beam shutter mechanisms must be interlocked to prevent operation if the shutter is not properly closed
- i) Post required notices and radiation warning signs
- j) Report unusual events/ exposures to EH&S Radiation Safety

### 9.02.2 Electron Microscopes and X-ray Fluorescence Units

Generally, electron microscopes and x-ray fluorescence units present little risk of significant radiation exposure if they are not modified or damaged and if the manufacturers operating instructions are followed. Requirements For The Safe Use Of Electron Microscopes And X-Ray Fluorescence Units Include:

- a) Follow the manufacturers operating instructions
- b) Stop operation and notify your supervisor if equipment is damaged (cracked windows) or if operating parameters are not within acceptable limits
- c) The radiation exposure limits for electron microscopes must not exceed 0.5 mR/hour at 2 cm from the surface
- d) Unless specified otherwise by EH&S Radiation Safety, radiation exposure monitors are not required for personnel who work with electron microscopes or x-ray fluorescence units

### 9.02.3 Medical Radiographic Machines

Most of the man-made, non-occupational radiation exposure received by the general population is during routine medical radiographic procedures. To satisfy the regulatory requirements related to medical radiography and to minimize the radiation exposure received by patients and workers during medical radiographic procedures, it is essential to comply with the following requirements/ safety practices:

- a) All x-ray equipment must satisfy appropriate requirements of federal, state and local regulations
- b) Shielding of x-ray rooms must satisfy appropriate requirements of federal, state and local regulations
- c) An "X-Ray On" warning light must be at each entrance
- d) Post operating/ safety instructions must be near the equipment console
- e) Patient radiography can be performed only when prescribed by a licentiate of the healing arts recognized by the State of California as a "Certified Supervisor/ Operator"
- f) Patient radiography can only be performed by a radiologic technologist certified by the State of California
- g) Equipment must be checked according to requirements of the State of California Radiation Control Regulations
- h) Personnel working with radiation must wear personnel monitors
- i) Only essential individuals can be in the x-ray room during the production of x-rays
- j) Any individual required in the room during the production of x-rays must wear a leaded apron of at least 0.25 mm lead equivalent, or stand behind an approved protective barrier
- k) If a patient must be held, the best choice is a non-pregnant parent or relative of the patient. Occupationally exposed individuals must not hold patients during x-ray exams, except in an emergency
- l) Any individual who holds a patient during an x-ray examination must wear a leaded apron (at least 0.25 mm lead equivalent) and, if the hands are likely to be in the primary beam, leaded gloves (at least 0.50 mm lead equivalent)
- m) Lead aprons, gloves, and other protective devices should be inspected once every six months to detect cracks and breaks in the shielding and should be replaced immediately if defects are found
- n) Collimate the x-ray beam to the area of interest, but no larger than the film size
- o) The technologist should inquire if a female patient is pregnant, particularly if the primary beam is likely to intercept the uterus
- p) Exposure of pregnant females should be avoided particularly if the beam is likely to intercept the uterus

- q) Use gonadal shielding if the reproductive organs are in the primary beam and if the shield will not interfere with the diagnostic information needed
- r) Fluoroscopists should never place their hands in the primary beam, and should wear gloves when hands are positioned near the primary beam
- s) Because of high radiation exposure to the patient during fluoroscopy, and especially during cineradiography, special care should be taken to minimize the beam on time
- t) All fluoroscopic units must be equipped with a manual reset timer that will sound a warning after a preset fluoro time not to exceed five minutes
- u) A technologist operating portable x-ray machines must wear a lead apron, stay out of the primary x-ray beam, be at least 6 feet from the beam during exposure and must be certain that all other individuals in the area are out of the primary beam and as far from the patient being x-rayed as possible

#### 9.02.4 Cabinet Radiography Units

By nature, cabinet radiography units present little risk of significant exposure if the shielding is not modified, if interlocks and warning lights operate properly, and if users follow approved operating procedures.

Requirements For The Safe Use Of Cabinet Radiography Units Include:

- a) Unless approved by the Radiation Safety Committee the radiation exposure at a distance of 2 cm from the surface of a cabinet radiography units must not exceed 0.5 mR/hour
- b) The necessity/ desirability for radiation dosimetry at each cabinet radiography unit will be determined by EH&S Radiation Safety

## **Appendices**



## **I. Statutes and Regulations**

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

### **Federal Statutes and Regulations**

- A. The U.S. Atomic Energy Act of 1954.
- B. The U.S. Radiation Control for Health and Safety Act of 1968.
- C. The 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, 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 20, Various Chapters.
- 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 Science Library.



## **II. Organization and Function of the Radiation Safety Committee**

### **Membership and Organization of RSC**

The RSC must consist of at least five academic members (all authorized users) appointed by the Chancellor, the campus Radiation Safety Officer and the Director of EH&S (ex-officio). Activities of the RSC are directed by its Chairperson. The Chair of the RSC must be a member of the Academic Senate. The Chair must convene the RSC as often as necessary to consider all aspects pertinent to radiation safety, or at least once per calendar quarter. A quorum must consist of a majority of the members. The chair of the RSC may appoint subcommittees to examine and recommend approval or disapproval of radiation use applications and renewals plus other duties authorized in the license.

### **Responsibilities of RSC**

The Committee is responsible for:

1. Ensuring that all individuals who work with or in the vicinity of radioactive material or radiation machines have sufficient training and experience 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 radiation machines are conducted in a safe manner and in accordance with the State of California regulations and the conditions of the license.

### **Duties of the RSC**

The Committee must:

1. 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. Establish a program to ensure all individuals, whose duties may require work in the vicinity of radioactive materials or radiation machines (clerical, emergency response, campus police, maintenance, and building services personnel), are properly instructed as required by CCR, Title 17, Section 30280.
3. Review the training and experience of individuals using radioactive material or radiation machines (including physicians, physicists, and pharmacists) and determine if qualifications are sufficient to enable them to perform their duties safely and in accordance with California regulations and the conditions of the license.
4. Review all requests for use of radioactive material within the institution.
5. Prescribe special conditions that will be required during a proposed use of radioactive material or radiation machines such as requirements for bioassays, physical examinations of users, and special monitoring procedures.
6. Review incidents and the radiation safety program periodically to determine that all activities are being conducted safely and in accordance with California regulations and the conditions of the license. The review must include an examination of pertinent records, reports from the RSO, results of California

inspection, written safety procedures and management control system.

7. Recommend remedial action to correct any deficiencies identified in the radiation safety program.
8. Maintain minutes of all committee meetings, actions, recommendations, and decisions.
9. Ensure that the radioactive material license is amended when necessary, prior to any changes in facilities, equipment, policies, procedures, and personnel.
10. Assure that EH&S Radiation Safety resources are adequate for its assigned duties.

### **Meetings**

The RSC must meet as often as necessary to conduct its business or at least once in each calendar quarter, and maintain minutes of its actions.

### III. Functions of EH&S Radiation Safety

1. General surveillance of all health physics activities, including both personnel and environmental monitoring.
2. Provide consulting services to personnel at all levels of responsibility and on all aspects of radiation protection.
3. Receive and inspect all radioisotopes shipped to and from UCR.
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/ intake. Notify individuals and their supervisors of exposures approaching or exceeding the "maximum permissible exposure" and recommend appropriate remedial action.
6. Assist with the training of university personnel who use radioactive materials. Topics include basic radiation/ health physics; use formal classroom courses or instructional aids.
7. Oversee the radioactive waste disposal program (includes pickup, storage, and disposal records).
8. Perform sealed source leak tests as required.
9. Maintain an inventory of all radioactive materials located at UCR 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/ renew RUA's on an annual basis.



#### IV. Review/ Approval Procedure for Applications Requesting the Use of Ionizing Radiation

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. All applications are evaluated according to the requirements of the State of California Radiation Control Regulations (CCR, Title 17) and conditions in the UCR broad scope license.
4. Final approval of all applications is by the RSC at a scheduled meeting. However, a preliminary approval can be granted if:
  - a) A quorum of the RSC members agrees to allow operation.

**OR**

- b) By the RSO, if all of the following conditions are met:
  - The applicant has been previously approved to use radioactive materials at UCR.
  - The application requests radioactive materials in quantities no greater than 20 times those specified as Exempt in Section 30235, Appendix B of the State of California Radiation Control Regulations (CCR, Title 17).
  - The application does not involve the use of human subjects, animals or radioactive nucleic acids.

#### Evaluation of Applications for Radioisotope Use

All applications for radioisotope use are assigned a Hazard Guide Value (HGV) as calculated using the equation and tables in Appendix V. The hazard guide value is intended to identify the degree of hazard associated with a project and is used to determine the:

1. Hazard Category:

The hazard category assigned to an authorization is based on the individual procedure (included on the application) with the highest HGV as calculated from the formula in Appendix V.

Hazard Category	Maximum Individual Procedure HGV
I	0 to <100
II	100 to <10,000
III	10,000 to <1,000,000
IV	1,000,000 or more

2. Facility and Containment Requirements:

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

### Specific Facility and Containment Requirements

	Procedure HGV	Type of Facility	Containment required Based On Potential Airborne Hazards**		
			substantial	minor	none
0	to <10	Low Act.*	open bench	open bench	open bench
10	to <100	Low Act.*	fume hood	open bench	open bench
100	to <1,000	Low Act.	fume hood	fume hood	open bench
1,000	to <10,000	Low Act.	fume hood	fume hood	fume hood
10,000	to <100,000	Medium Activity box	glove hood	fume hood	fume
100,000	to <1,000,000	Medium Activity box	glove box	glove hood	fume
1,000,000	or more	High Activity box	glove box	glove box	glove

\* Exemptions from specific requirements may be approved by the RSO, as necessary and appropriate when the HGV is <100.

\*\* Potential Airborne Hazards:

- Substantial- Procedures with significant aerosol production, dust generation, (respirable size particles) or volatile compounds.
- Minor- Procedures with limited aerosol production, dust generation, (non-respirable sized particles), or a low volatility component.

#### 3. Level Of Review Needed:

The level of internal review is determined by the assigned HGV as follows.

Hazard Category	Minimum RUA Reviewer(s)	
	Original RUA	Renewals/Amendments
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

A member of the RSC may request a higher level of review for any RUA

#### 4. Health Physics Audits:

The frequency of health physics audits is based on the Hazard Category assigned to an authorization.

Hazard Category	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 new RUAs, and to renewal RUAs with research programs involving routine uses of substantial quantities of radioisotopes. The reviewing health physicist may, at his/her discretion, assign Subcategory B for renewal RUAs in research programs involving only occasional uses of radioisotopes, or where most radioactive materials are in storage for long periods of time.

5. User Surveys:

The frequency of user surveys is based on the Hazard Category assigned to the lab.

Hazard Category	Survey Frequency
I	Monthly*
II	Weekly*
III	Daily
IV	Daily or continuous as required

\* If work with radioactive materials is occasional, a survey must be performed after each use or quarterly, whichever is more frequent.



## V. Determination of Hazard Guide Value (HGV)

$$HGV = \frac{QxUxSxC}{T}$$

Where:

- Q = Quantity of radioactive material used per procedure in uCi
- U = Use factor from Attachment 1 for unsealed sources or Attachment 2 for sealed sources
- S = Special hazard factors from Attachments 1 or 2 as appropriate
- C = Containment factors from Attachments 1 or 2 as appropriate
- T = Annual Limits of Intake (ALI) from ICRP Publication 30 and its supplements, or other recognized source(s), in uCi, rounded to two significant figures

**ATTACHMENT 1 for APPENDIX V**  
**Modifying Factors for Operations with Unsealed Radioactive Materials**

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

**ATTACHMENT 2 for APPENDIX V**  
**Modifying Factors for Operations with Sealed (encapsulated) Radioactive Materials**

**Modifying Conditions**

**Multiplication Factors**

**Use Factors**

- |  |                                     |
|--|-------------------------------------|
| <ul style="list-style-type: none"> <li>• Experimental procedures with sealed sources</li> <li>• Storage of sealed sources in unshielded area</li> <li>• Operation of Irradiator with internal chamber, and storage of sealed sources in shielded area</li> </ul> | <p>0.1</p> <p>0.01</p> <p>0.001</p> |
|--|-------------------------------------|

**Special Hazard Factors**

The Special Hazard Factor for a gamma 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 or neutron radiation, the special hazard factor will be the sum of the individual special hazard factors for the different types of radiation.

**Containment Factors**

- |   |                                     |
|---|-------------------------------------|
| <ul style="list-style-type: none"> <li>• Single encapsulation with mylar or plastic covering:</li> <li>• Single encapsulation in strong metal container, or double encapsulation in strong metal containers, with one or both containers not welded closed under an inert gas atmosphere</li> <li>• Double encapsulation in strong metal containers, with both containers welded closed under an inert gas atmosphere:</li> </ul> | <p>0.1</p> <p>0.01</p> <p>0.001</p> |
|---|-------------------------------------|

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

The RSO administers the campus Radiation Safety Program under the general direction of the RSC, using its resources. Duties include the following:

1. Communicate the Federal/ State requirements for the safe use of radiation.
2. Prepare a Radiation Safety Manual to serve as a statement of UCR policy and practice regarding the use of ionizing radiation.
3. Serve as liaison between UCR and Federal/ State regulatory agencies.
4. Direct the functions of EH&S Radiation Safety.
5. Oversee radioactive waste disposal activities.
6. Review applications for new/ modified uses of radioactive materials and radiation producing machines before use.
7. Review projects and inspect facilities to determine the level of compliance with the pertinent regulations and any conditions specified by the RSC.
8. Investigate incidents and, where necessary, direct corrective action.
9. Develop emergency response plans, operational procedures and coordinate radiation related activities during an emergency.
10. Provide 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. Maintain appropriate records of EH&S Radiation Safety operations for inspection by appropriate agency(ies).
12. Conduct training programs and in-service updates.
13. Serve as secretary to and maintains records for RSC.
14. Perform any other activity assigned by the RSC.

## VII. Responsibilities of the Principal Investigator (PI)

The following list is representative but not intended to be exhaustive.

1. Apply to the Radiation Safety Committee 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 prior to initiating the procedure.
3. All PI's, or their delegated alternate, must provide specific instruction on all aspects of radiation safety that apply to the specific procedure(s) involved. In addition, all untrained personnel must attend the general training session on radiation safety provided by EH&S Radiation Safety.
4. Inform the RSO when individuals, activities, or locations covered by an RUA are changed.
5. Implement approved procedures for the procurement of radioactive materials by purchase or transfer.
6. Post areas where radioactive materials are stored or used.
7. When required, post areas where radiation exposures exist.
8. Properly record the receipt, transfer and disposal of radioactive material, including sealed sources.
9. Properly store and prepare radioactive waste for collection by EH&S.
10. When required, assure that radiation users under supervision are properly monitored for internal or external exposure.
11. Minimize the stock of stored radioactive materials within the work/ laboratory area.
12. 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 assure that the area is free of contamination
  - d) Request that EH&S Radiation Safety perform a closeout survey before leaving the campus
13. Assure that a copy of the Radiation Safety Manual is available to all personnel engaged in work with ionizing radiation.
14. Enforce the use of personnel monitoring devices, survey meters, personal protective equipment, and engineering controls as specified in the Radiation Safety Manual or by the RSC.



## VIII. Responsibilities of the Designated User (DU)

Designated users who handle radioactive materials or use radiation producing machines can fulfill their responsibility for their own safety and those around them if they:

- A. Follow procedures/ protocols and are certain that training, and safety equipment, etc. are adequate. Check with the PI or RSO if there are questions.
- B. Keep exposure to radiation as low as reasonably achievable, but also below the "Maximum Permissible Exposures" specified in this manual.
- C. Minimize airborne radioactive contamination by use of available engineering controls such as fume hoods.
- D. Wearing prescribed monitoring equipment, such as film and ring badges, when required.
- E. Informing the PI or RSO of any unsafe conditions known to exist.
- F. Follow 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 for all situations, but with slight modifications the following can satisfy most needs:

- 1. Radiation work and storage areas must be separated 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 are forbidden.
- 4. Cover all work areas with absorbent paper as a protection against spills.
- 5. Provide necessary shielding.
- 6. Place waste materials in containers as specified in this manual.
- 7. Maintain good housekeeping throughout the laboratory.
- 8. Restrict against all possible personal contamination:
  - a) Wear rubber gloves and use tongs
  - b) Use remote pipetting technique
  - c) Do not work when open skin wounds can be contaminated
  - d) Prohibit lunchroom activities in radioactive area
  - e) Wear laboratory clothes over street clothes
- 9. Clearly mark all contaminated glassware or equipment until it has been decontaminated.
- 10. Restrict volatile materials to special fume hoods, and powders to gloved boxes.
- 11. Keep all intermediate levels of radioactive materials away from counting areas.
- 12. Label work areas, materials, and containers as required by law.
- 13. Learn what instruments are effective for monitoring and how to use them. Then monitor any suspect equipment or operation to assure safety. You cannot know it

is safe unless you have monitored.

14. 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.

15. Wash hands and check with suitable survey meter before leaving laboratory.

G. Additional Requirements for High Hazard Procedures (See Appendix IV, 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. 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.

## IX. Ordering of Radioactive Materials and Radiation Producing Machines

All purchases of sources that emit or produce ionizing radiation must be pre-approved by EH&S Radiation Safety as follows:

- A. A purchasing agent will call or Fax a request, that includes the following information, to EH&S Radiation Safety:
  1. Name of Purchasing Agent
  2. Name of PI
  3. Department name
  4. Vendor/ Manufacturer
  5. Purchase order number
  6. Quantity
  7. Description:
    - a) If Materials:
      - Isotope
      - Chemical compound
      - Activity (in mCi, or uCi)
    - b) If Machines:
      - Type of equipment
      - Manufacturer and model number
      - Maximum energy (kVp)
      - Maximum current/ intensity (mA, particles/ pulse and pulses/sec)
- B. EH&S Radiation Safety will review and approve\*, if appropriate. Approved requests will be logged into the Acquisition Log. If there are questions, EH&S Radiation Safety will contact the PI to resolve any differences.
- C. When a request is approved, the department Purchasing Agent completes the PO, places the order, and forwards the pink copy to EH&S Radiation Safety. When completing the PO and placing the order, identify the delivery location as the EH&S Building.
- D. Materials are delivered to EH&S Radiation Safety where the packing slip is removed, and the package is checked for leakage, exposure levels, and contamination. Machines are delivered directly to the lab or radiation facility, but EH&S Radiation must be notified at arrival and before use.
- E. Information on the packing slip is checked against that recorded in Acquisition Log, to verify that the items received are the same as those approved/ ordered.
- F. If the paperwork agrees: 1) The package is delivered to the user 2) The user/ representative signs and dates the packing slip 3) EH&S Radiation Safety stamps the packing slip "Received and Delivered".
- G. EH&S Radiation Safety will send signed packing slips to the appropriate department Purchasing agent.

\* Items included on "blanket" orders need to be approved only prior to the initial order. When shipments arrive they will be treated as any other item, see items 4 to 7.



## **X. Package Opening/ Monitoring Procedure:**

### **Instructions for EH&S Radiation Safety During Initial Receipt:**

1. Log package in acquisition log.
2. Visually inspect package for any signs of damage (wetness, odor, crushed). If damage is noted, stop procedure, note condition in acquisition log, and notify RSO or designee<sup>\*\*\*</sup>.
3. If leakage or contamination is suspected, determine the extent by wiping the external surface of the container with an absorbent material (filter paper), measure the activity<sup>\*</sup>, and record results in the acquisition log. If removable radioactive contamination is less than the limits specified for uncontrolled areas in Section 5.11, the package is considered uncontaminated. If measured levels fall between those specified for controlled and uncontrolled areas, the package is labeled as contaminated and the RSO or designee is notified<sup>\*\*\*</sup>. If measured levels are in excess of the levels allowed for controlled areas, stop procedure and notify the RSO or designee<sup>\*\*\*</sup>.
4. Measure the exposure rate<sup>\*\*</sup> at one meter from the package surface and record in the acquisition log. If  $>10$  mR/hr or twice the Transport Index {defined as the dose equivalent rate (mrem/hour) at 1 meter from the surface}, note it on the package or paper, stop procedure and notify the RSO or designee<sup>\*\*\*</sup>.
5. Measure the surface exposure rate<sup>\*\*</sup> and record in the acquisition log. If  $>200$  mR/hr, stop procedure and notify the RSO or designee<sup>\*\*\*</sup>.
6. Remove the packing slip from the package. Open the inner package to verify contents. Record the shipped activity and calibration date in the acquisition log. Compare information on the isotope request with that on the packing slip and container label and note any inconsistencies in the acquisition log. Check the integrity of the final source container (inspect for broken seals on vials, loss of liquid, discoloration of packaging material, etc.) and note damage or inconsistencies found in the acquisition log. Notify the RSO or designee<sup>\*\*\*</sup> if inconsistencies or problems are noted.
7. Monitor<sup>\*</sup> the packing material and/or wipe container surfaces to check for contamination and record results in the acquisition log.
  - a) If contaminated<sup>\*\*\*\*</sup> notify the supplier, transporter, purchaser, state, etc. as required.
  - b) If uncontaminated, or if the measured activity is less than that allowed in controlled areas<sup>\*\*\*\*</sup>, repack and reseal the shipping package.
8. Deliver package to appropriate lab.

### **Instructions for PI Following Delivery By EH&S Radiation Safety:**

1. Inspect package for damage.
2. If damage is noted call EH&S Radiation Safety.
3. Log shipment in the Receipt Log.
4. If inconsistencies are noted, call EH&S Radiation Safety.

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- \* Exposure measurements are to be performed in a low-background area using detectors suitable for the radiation to be measured, typically an ion chamber or GM survey meter calibrated in mR/hr for the energy of the radiation being measured.
- \*\* Contamination surveys/ wipe analyses are to be performed in a low-background area using detectors suitable for the radiation to be measured, typically a liquid scintillation counter for low and medium energy beta emitters, a thin window GM survey meter (<7mg/cm<sup>2</sup> thickness) for medium energy beta emitters, and properly calibrated scintillation detector for gamma emitters.
- \*\*\* The RSO or designee will take necessary actions; notification will include the requestor, shipper, supplier, and State agencies as appropriate/ required.
- \*\*\*\* If removable radioactive contamination is less than the limits specified for uncontrolled areas in Section 5.11, the package is considered uncontaminated. If measured levels fall between those specified for controlled and uncontrolled areas, the package is labeled as contaminated and the RSO or designee is notified<sup>\*\*\*</sup>. If measured levels are in excess of the levels allowed for controlled areas stop procedure and notify the RSO or designee<sup>\*\*\*</sup>.

## XI. Area Surveys and Monitoring

### 1. Areas with sealed sources:

- a) If sealed sources that could reasonably result in exposures greater than 25% of the limits specified in Section 4.01 are used, a measurement of radiation levels must be made with a survey meter sufficiently sensitive to detect 0.1 mrem/hr.
- b) Corrective action will be taken and a resurvey performed if external exposure levels exceed limits specified in Section 4.01, or otherwise specified in the RUA.

### 2. Areas with unsealed sources:

- a) If unsealed sources are used, a series of wipes is required to measure contamination levels. The methods for performing wipe tests will be sufficiently sensitive to detect the activities specified in Section 5.11 for the contaminant involved.
- b) An area will be decontaminated and resurveyed if the contamination levels exceed those specified in Section 5.11.

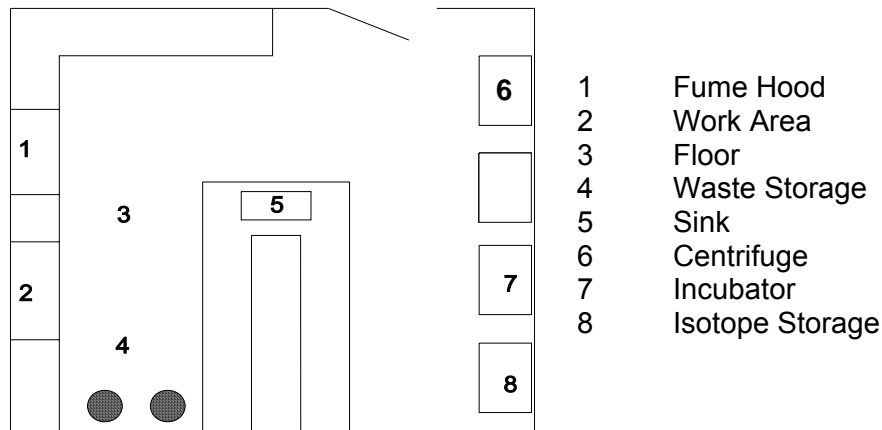
### 3. Records:

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

- a) Location, date and type of equipment used
- b) Name of person conducting the survey
- c) Drawing of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.
- d) Measured exposure rates, and detected contamination levels keyed to location on the drawing
- e) Corrective action taken in case of contamination or excessive exposure rates, and the reduced contamination levels or exposure rates after corrective action

## Routine Radiation Survey Report

Typical Lab Plan





## **XII. Laboratory Audits**

Laboratories using radioactive materials are to be audited annually, or as determined necessary by the RSC or by EH&S Radiation Safety. This audit will be on or about the anniversary of the original approval date for the regular authorized user. The audit will consist of verification that required records are maintained and current, lab safety procedures are followed, safety notifications are posted, and the use of radioisotopes is in accordance with the individual authorization. Also included in the audit will be a contamination survey. A report will be kept on file in EH&S Radiation Safety and a copy sent to the authorized user.

### **Records**

The following records are to be maintained by the authorized user:

1. A copy of the user's application(s) for use of a radioisotope(s), and any amendments to that application.
2. A copy of the approval by the RSC and any amendments.
3. A copy of the RSM.
4. Receipts of radioisotope purchases, including any radioactive materials transferred from one authorized user to another.
5. Copies of the Annual Authorization Update Report sent by EH&S Radiation Safety.
6. A record of all radioisotope uses 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 radiation dosimetry reports (where applicable).
9. A statement of "training and experience" for each person handling radioisotopes.
10. Records of laboratory contamination self-surveys. A map of the lab showing survey locations, survey results, survey instruments used and survey date.

### **Posted Instructions**

As appropriate, all laboratories must have signs posted at all entrances indicating the use or presence of radioactive materials. In addition, all work areas, including tabletops and equipment, used in radioisotope procedures must be labeled as potentially contaminated. Storage areas, such as refrigerators, must be properly labeled. Containers of used/ waste radioactive materials and discarded contaminated lab items must be properly labeled.

All laboratory areas must post: 1) the "Notice to Employees" sign (CCR, Title 17) detailing the standards for protection against radiation hazards, 2) routine laboratory procedures, and 3) emergency laboratory procedures.

### **Contamination Survey**

The contamination survey will consist of wipes taken in areas where removable contamination is likely to be or present a hazard (work areas, storage areas, floors, drains, door handles and equipment used in the process of handling isotopes). A map of the lab showing the location of each wipe should accompany the report. The survey map should

include the lab location (room #), identify use, storage and disposal areas, and the date of the survey.

Wipes will be taken from an area of 100 cm<sup>2</sup> with smears appropriate for a liquid scintillation counter, windowless gas-flow proportional counter, thin window G-M counter, or scintillation counter as appropriate. Instruments used to count the wipes will be calibrated every six months and the lower limit of detection determined.

Results of the survey will be recorded so as to allow determination of dpm per 100 cm<sup>2</sup>.

### **Noncompliance**

A report will be issued by EH&S Radiation Safety detailing the non-compliance item(s) in need of correction and the action required. A timetable will be identified as to when corrections must be made and a date for re-inspection will be arranged. Chronic noncompliance could result in an administrative review by the RSC and may lead to cancellation of the authorization to use radioactive materials or radiation sources.

### XIII. Radioactive Waste Segregation Guidelines

To manage radioactive waste efficiently according to state regulations and license conditions, the waste must be segregated according to type at the point of generation as indicated below. Recognize that within each category the concentrations of all additions to a waste container should be similar (avoid mixing high and low concentration wastes), and that by nature, a list can't include every possibility so, if questions arise, call EH&S Radiation Safety at ext. 2-5529.

1. Dry solid:
  - a) Short\* half-life
  - b) Long half-life
2. Liquid:
  - a) Short\* half-life;
    - Aqueous
    - Organic/ hazardous
  - b) Long half-life;
    - H-3 and/or C-14 liquid scintillation cocktails <0.05 uCi/ml.
    - Other
      - Aqueous
      - Organic/ hazardous
3. Biological\*\* (animal carcasses/ medical waste):
  - a) Short\* half-life
  - b) Long half-life;
    - H-3 and/or C-14 with <0.05 uCi/g or ml
    - Other
4. Sharps (needles, broken glass, pipette tips):
  - a) Short\* half-life
  - b) Long half life
5. Stock vials (empty or full):
  - a) Short\* half-life
  - b) Long half-life
6. Sealed sources.

**The Only Exception(s)** to the above segregation scheme should be mixtures that are produced as a result of a procedures/ processes. If there are questions call EH&S Radiation Safety.

\* Typically less than 30 days often extended to 90 days. Call EH&S Radiation Safety (ext. 2-5529) for information.

\*\* Must be refrigerated if held for more than 24 hours before pickup by EH&S Radiation Safety.



## Tables



**Table I**  
**Classification of Isotopes According to Relative**  
**Radiotoxicity per Unit of Activity**

(The isotopes in each radiotoxicity class are listed in order of increasing atomic number.)

Radiotoxicity	Isotopes
Very High	Sr-90 +Y-90, *Pb-210 + Bi-210 (Ra D + E), Po-210, At-211, Ra-226 + 55 % *daughter products, Ac-227, *U-233, Pu-239, *Am-241, Cm-242 plus other transuranic isotopes
High	Ca-45, *Fe-59, Sr-89, Y-91, Ru-106 + *Rh-106, *I-125, *I-131, *Ba-140, La-140, Ce-144 + *Pr-144, Sm-151, *Eu-154, *Tm-170, *Th-234 + *Pa-234, natural uranium
Moderate	*Na-22, *Na-24, P-32, P-33, S-35, Cl-36, *K-42, *Sc-46, Sc-47, *Sc-48, *V-48, *Mn-52, *Mn-54, *Mn-56, Fe-55, *Co-57, *Co-58, *Co-60, Ni-59, Ni-63, *Cu-64, *Zn-65, *Ga-72, *As-74, *As-76, *Br-82, *Rb-86, *Zr-95 + *Nb-95, *Nb-95, *Mo-99, Tc-98, *Tc-99m, *Rh-105, Ru-103 + Rh-103, *Ag-105, Ag-111, Cd-108, *Ag-109, *Sn-113, *Te-127, *Te-129, I-132, Cs-137 + *Ba-137, *Ce-141, *La-140, Pr-143, Pm-147, *Ho-166, *Lu-177, *Ta-182, *W-181, *Re-183, Ir-190, *Ir-192, Pt-191, *Pt-193, *Au-196, *Au-198, *Au-199, Tl-200, Tl-202, Tl-204, *Pb-203, Rn-222
Slight	H-3, *Be-7, C-14, F-18, *Cr-51, Ge-71, *In-111, *In-113m, *Xe-133, *Tl-201, U-238

\* Emit gamma(s) or X-rays in significant amounts

**Table II**  
**Exempt Quantities as Defined in Title 17, CCR**

<u>Rad. Iso.</u>	<u>uCi</u>	<u>Rad. Iso.</u>	<u>uCi</u>	<u>Rad. Iso.</u>	<u>uCi</u>
Ag-105	10	I-131	1	Sb-124	10
Ag-110m	1	I-132	10	Sb-125	10
Ag-111	100	I-133	1	Sc-46	10
Am-241	0.1	I-134	10	Sc-47	100
As-73	100	I-135	10	Sc-48	10
As-74	10	In-113m	100	Se-75	10
As-76	10	In-114m	10	Si-31	100
As-77	100	In-115	10	Sm-151	10
Au-198	100	In-115m	100	Sm-153	100
Au-199	100	Ir-192	10	Sn-113	10
Ba-131	10	Ir-194	100	Sn-125	10
Ba-133	10	K-42	10	Sr-85	10
Ba-140	10	Kr-85	100	Sr-89	1
Be-7	100	Kr-87	10	Sr-90	0.1
Bi-210	1	La-140	10	Sr-91	10
Br-82	10	Lu-177	100	Sr-92	10
C-14	100	Mn-52	10	Ta-182	10
Ca-45	10	Mn-54	10	Tb-160	10
Ca-47	10	Mn-56	10	Tc-96	10
Cd-109	10	Mo-99	100	Tc-97	100
Cd-115	100	Na-22	1	Tc-97m	100
Cd-115m	10	Na-24	10	Tc-99	10
Ce-141	100	Nb-93m	10	Tc-99m	100
Ce-143	100	Nb-95	10	Te-125m	10
Ce-144	1	Nb-97	10	Te-127	100
Cl-36	10	Nd-147	100	Te-127m	10
Cl-38	10	Nd-149	100	Te-129	100
Co-58	10	Ni-59	100	Te-129m	10
Co-58m	10	Ni-63	100	Te-131m	10
Co-60	1	Ni-65	100	Te-132	10
Cr-51	1000	Os-185	10	Th-natural	50
Cs-131	1000	Os-191	100	Tl-200	100
Cs-134	1	Os-191m	100	Tl-201	100
Cs-134m	100	Os-193	100	Tl-202	100
Cs-135	10	P-32	10	Tl-204	10
Cs-136	10	Pb-210	0.1	Tm-170	10
Cs-137	10	Pd-103	100	Tm-171	10
Cu-64	100	Pd-109	100	U-233	0.01
Dy-165	10	Pm-147	10	U-234/235	0.01
Dy-166	100	Pm-149	10	U-natural	50
Er-169	100	Po-210	0.1	V-48	10
Er-171	100	Pr-142	100	W-181	10
Eu-152,13y	1	Pr-143	100	W-185	10
Eu-152,9.2h	100	Pt-191	100	W-187	100
Eu-154	1	Pt-193	100	Xe-131m	1000
Eu-155	10	Pt-193m	100	Xe-133	100
F-18	1000	Pt-197	100	Xe-135	100
Fe-55	100	Pt-197m	100	Y-90	10
Fe-59	10	Pu-239	0.01	Y-91	10
Ga-72	10	Ra-226	0.01	Y-92	100
Gd-153	10	Ru-103	10	Y-93	100
Gd-159	100	Ru-105	10	Yb-175	100
Ge-71	100	Ru-106	1	Zn-65	10
H-3	1000	Rb-86	10	Zn-69	1000
Hf-181	10	Rb-87	10	Zn-69m	100
Hg-197	10	Re-186	100	Zr-93	10
Hg-197m	100	Re-188	100	Zr-95	10
Hg-203	10	Rh-103m	100	Zr-97	10
Ho-166	100	Rh-105	100		
I-125	1	Rh-97	100	Any non-alpha emitter not listed	0.1
I-126	1	S-35	100		
I-129	0.1	Sb-122	100		

**Table III**  
**Limits for Removable Surface Contamination\***

TYPE OF SURFACE	Type of Radioactive Material**		
	ALPHA EMITTERS (dpm/100cm <sup>2</sup> )	BETA, X-RAY, OR GAMMA EMITTERS (dpm/100cm <sup>2</sup> )	LOW-RISK BETA, X-RAY, OR GAMMA EMITTERS (dpm/100cm <sup>2</sup> )
Uncontrolled areas	22	220	2,200
Controlled areas	220	2,200	22,000
Personal clothing worn outside controlled areas	22	220	2,200
Protective clothing worn only in controlled areas	220	2,200	22,000
Skin	220	220	220

\* As adapted from Table II from Reg. Guide 8.23, Jan '81. Averaging is acceptable over inanimate areas of up to 300 cm<sup>2</sup>, or for floors, walls, ceiling, 100 cm<sup>2</sup>. Averaging is also acceptable over 100 cm<sup>2</sup> for skin or, for the hands, over the whole area of the hand, nominally 300 cm<sup>2</sup>.

\*\* Beta or x-ray emitter values are applicable for all beta or x-ray emitters other than those considered low risk. Low-risk nuclides include C-14, H-3, Tc-99m, and others whose beta energies are <0.2 MeV maximum, whose gamma or x-ray emission is <0.1 R/h at 1 meter per curie, and whose permissible concentration in air (see 10 CFR Part 20, Appendix B, Table I) is >10<sup>-6</sup> uCi/ml.



## References

The following handbooks are NCRP Reports and are available from:

NCRP Publications  
7910 Woodmont Avenue, Suite 800  
Bethesda, MD 20814

### NCRP Report #/ Title

- 8 Control and Removal of Radioactive Contamination in Laboratories (1951)
- 9 Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users (1951)
- 10 Radiological Monitoring Methods and Instruments (1952)
- 12 Recommendations for the Disposal of Carbon-14 Wastes (1953)
- 16 Radioactive Waste Disposal in the Ocean (1954)
- 22 Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure (1959) (Includes Addendum 1 issued in August 1963)
- 23 Measurement of Neutron Flux and Spectra for Physical and Biological Applications (1960)
- 25 Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays (1961)
- 27 Stopping Powers for Use with Cavity Chambers (1961)
- 28 A Manual of Radioactivity Procedures (1961)
- 30 Safe Handling of Radioactive Materials (1964)
- 32 Radiation Protection in Educational Institutions (1966)
- 33 Medical X-ray and Gamma-ray Protection for Energies up to 10 MeV - Equipment Design and Use (1968)
- 35 Dental X-ray Protection (1970)
- 36 Radiation Protection in Veterinary Medicine (1970)
- 37 Precautions in the Management of Patients Who have Received Therapeutic Amounts of Radionuclides (1970)
- 38 Protection Against Neutron Radiation (1971)
- 39 Basic Radiation Protection Criteria (1971)
- 40 Protection Against Radiation From Brachytherapy Sources (1972)
- 41 Specifications of Gamma-Ray Brachytherapy Sources (1974)
- 42 Radiological Factors Affecting Decision-Making in a Nuclear Attack (1974)
- 43 Review of the Current State of Radiation Protection Philosophy (1975)
- 44 Krypton-85 in the Atmosphere - Accumulation, Biological Significance, and Control Technology (1975)
- 45 Natural Background Radiation in the United States (1975)
- 46 Alpha-Emitting Particles in Lungs (1975)
- 47 Tritium Measurement Techniques (1976)
- 48 Radiation Protection for Medical and Allied Health Personnel (1976)
- 49 Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma-Rays of Energies up to 10 MeV (1976)
- 50 Environmental Radiation Measurements (1976)
- 51 Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities (1977)
- 52 Cesium-137 From the Environment to Man: Metabolism and Dose (1977)
- 53 Review of NCRP Radiation Dose Limit for Embryo and Fetus in Occupationally-Exposed Women (1977)

- 54 Medical Radiation Exposure of Pregnant and Potentially Pregnant Women (1977)
- 55 Protection of the Thyroid Gland in the Event of Releases of Radioiodine (1977)
- 56 Radiation Exposure From Consumer Products and Miscellaneous Sources (1977)
- 57 Instrumentation and Monitoring Methods for Radiation Protection (1978)
- 58 A Handbook of Radioactivity Measurements Procedures, 2nd ed. (1985)
- 59 Operational Radiation Safety Program (1978)
- 60 Physical, Chemical, and Biological Properties of Radiocerium Relevant to Radiation Protection Guidelines (1978)
- 61 Radiation Safety Training Criteria for Industrial Radiography (1978)
- 62 Tritium in the Environment (1979)
- 63 Tritium and Other Radionuclide Labeled Organic Compounds Incorporated in Genetic Material (1979)
- 64 Influence of Dose and Its Distribution in Time on Dose-Response Relationships for Low-LET Radiations (1980)
- 65 Management of Persons Accidentally Contaminated with Radionuclides (1980)
- 66 Mammography (1980)
- 67 Radiofrequency Electromagnetic Fields - Properties, Quantities and Units, Biophysical Interaction, and Measurements (1981)
- 68 Radiation Protection in Pediatric Radiology (1981)
- 69 Dosimetry of X-Ray and Gamma-Ray Beams for Radiation Therapy in the Energy Range 10 keV to 50 MeV (1981)
- 70 Nuclear Medicine - Factors Influencing the Choice and Use of Radionuclides in Diagnosis and Therapy (1982)
- 71 Operational Radiation Safety - Training (1983)
- 72 Radiation Protection and Measurement for Low Voltage Neutron Generators (1983)
- 73 Protection in Nuclear Medicine and Ultrasound Diagnostic Procedures in Children (1983)
- 74 Biological Effects of Ultrasound: Mechanisms and Clinical Implications (1983)
- 75 Iodine-129: Evaluation of Releases from Nuclear Power Generation (1983)
- 76 Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment (1984)
- 77 Exposures from the Uranium Series with Emphasis on Radon and its Daughters (1984)
- 78 Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States (1984)
- 79 Neutron Contamination from Medical Electron Accelerators (1984)
- 80 Induction of Thyroid Cancer by Ionizing Radiation (1985)
- 81 Carbon-14 in the Environment (1985)
- 82 SI Units in Radiation Protection and Measurements (1985)
- 83 The Experimental Basis for Absorbed-Dose Calculations in Medical Uses of Radionuclides (1985)
- 84 General Concepts for the Dosimetry of Internally Deposited Radionuclides (1985)
- 85 Mammography - A User's Guide (1986)
- 86 Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields (1986)
- 87 Use of Bioassay Procedures for Assessment of Internal Radionuclide Deposition (1987)
- 88 Radiation Alarms and Access Control Systems (1987)
- 89 Genetic Effects of Internally Deposited Radionuclides (1987)
- 90 Neptunium: Radiation Protection Guidelines (1987)
- 91 Recommendations on Limits for Exposure to Ionizing Radiation (1987)
- 92 Public Radiation Exposure from Nuclear Power Generation in the United States (1987)
- 93 Ionizing Radiation Exposure of the Population of the United States (1987)
- 94 Exposure of the Population in the United States and Canada from Natural Background

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- Radiation (1987)
- 95 Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources (1987)
- 96 Comparative Carcinogenesis of Ionizing Radiation and Chemicals (1989)
- 97 Measurement of Radon and Radon Daughters in Air
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## Glossary

### A

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**Airborne Radioactive Material:** Any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases.

**Airborne Radioactivity Area:** Any room, enclosure, or operating area in which airborne radioactive material exists in concentrations:

- 1) In excess of those specified in Title 17, Section 30355, Appendix A, Table I, Column 1  
**or**
- 2) Which averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of those specified in Title 17, Section 30355, Appendix A, Table I, Column 1

**ALARA:** See As Low As Reasonably Achievable.

**ALI:** Annual limit of intake.

**As Low As Reasonably Achievable (ALARA):** The concept that while radiation exposures should never exceed regulatory limits, prudence dictates that effort be expended to maintain actual exposures below these levels as much as possible since the effects of low exposures to radiation are not completely understood.

### C

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**Calendar Quarter:** Not fewer than 12 consecutive weeks nor more than 14 consecutive weeks. Calendar quarters must be arranged so that no day in any year is omitted from inclusion within a calendar quarter. For reasons of personnel dosimetry, quarters begin January 1, April 1, July 1, and October 1.

**Controlled Area:** Any area where access is controlled by the user for purposes of radiation safety pursuant to the provisions of this regulation. Airborne radioactivity areas, high radiation areas, and radiation areas must be considered controlled areas. Controlled areas must not include any areas used as residential quarters.

**Curie:** The unit of radioactivity. One curie is the activity corresponding to a disintegration rate of  $3.7 \times 10^{10}$  disintegrations per second except that, for the purposes of this regulation, 6615 pounds of natural or depleted uranium or 19,850 pounds of natural thorium must be considered equivalent to one curie.

### D

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**Dose:** Radiation energy absorbed per unit mass. When a dose to the whole body is specified, this must be considered to mean any dose to the whole body or major portion thereof, head and trunk, gonads, lens of the eye, or active blood-forming organs.

**Declared Pregnant Woman:** A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

**Designated User (DU):** An individual who is listed on a RUA as a radiation user and has been properly trained to use the sources being used.

**DU:** See Designated User.

## E

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**EH&S:** Environmental Health and Safety.

**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.

## H

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**Half-Life:** The time for the number of radioactive atoms and the radiation intensity to decrease to one-half of its original value.

**HGV:** Hazard guide value.

**High Radiation Area:** Any area, accessible to individuals, in which there exists radiation at such levels that an individual could receive in any one hour a dose to the whole body in excess of 100 millirem.

**Human Use:** Radioactive materials used for the purpose of diagnosis, evaluating physiological function, monitoring evolution of disease processes, following response to therapeutic intervention and/or evaluating risk factors in humans.

## I

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**ICRP:** International Commission on Radiological Protection.

**Ionizing Radiation:** See Radiation.

## N

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**NCRP:** National Council of Radiation Protection and Measurements.

**Non-Occupational Dose/ Exposure:** An exposure/ dose received by an individual who does not work directly with radiation (office worker, maintenance person, building services person, visitor, etc.)

## O

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**Occupational Dose/ Exposure:** The dose received by any individual in a controlled area or in the course of employment, education, training, or other activities which involve exposure to radiation. Occupational dose must not include the dose from exposure to radiation for the purpose of medical or dental diagnosis or medical therapy of such individual.

## P

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**Personnel Monitoring Equipment:** Devices designed to be worn or carried by an individual for the purpose of measuring the dose received (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.

**PI:** See Principal Investigator.

**PPE:** See personal protective equipment.

**Principal Investigator (PI):** An individual, usually a faculty member, who has been authorized by the RSC to use radiation sources.

## R

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**Rad:** 100 ergs of energy absorbed per gram. This is about the rate of energy absorbed from 1 roentgen of x- or gamma rays near the surface of the body.

**Radiation:** Gamma rays and X-rays, alpha and beta particles, neutrons, protons, high-speed electrons, and other nuclear particles, but not sound or radio waves, or visible, infrared, or ultra-violet light.

**Radiation Area:** Any area, accessible to individuals, in which there exists radiation at such levels that an individual could receive in any one hour a dose to the whole body in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirem.

**Radiation Machine:** Any device capable of producing radiation when the associated control devices are operated, but excluding devices which produce radiation only by the use of radioactive material.

**Radiation Safety Committee (RSC):** A committee appointed by UCR administration, and granted authority by the State of California to Authorize and control the use of radiation at UCR.

**Radiation Safety Officer (RSO):** An individual appointed by the RSC and UCR administration to manage the Radiation Safety Program at UCR.

**Radiation Use Authorization (RUA):** An authorization to use radiation, granted by the RSC to a PI.

**Rem:** A unit of dose of any radiation to body tissue in terms of its estimated biological effects relative to an exposure of one roentgen of X-rays or gamma rays. For the purpose of this regulation, any of the following is considered to be equivalent to a dose of one rem:

- 1) An exposure of one roentgen due to X or gamma radiation
- 2) A dose of one rad due to X, gamma, or beta radiation
- 3) A dose of 0.1 rad due to neutrons or high-energy protons
- 4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye
- 5) An exposure of  $14 \times 10^6$  neutrons per square centimeter, or in accordance with the following table if the energy of the neutrons is known:

Neutron Energy (MeV)	Number of neutrons per sq. cm equivalent to a dose of 1 rem
Thermal	$970 \times 10^6$
0.0001	$720 \times 10^6$
0.005	$820 \times 10^6$
0.02	$400 \times 10^6$

0.1	120 x 10 <sup>6</sup>
0.5	43 x 10 <sup>6</sup>
1.0	26 x 10 <sup>6</sup>
2.5	29 x 10 <sup>6</sup>
5.0	26 x 10 <sup>6</sup>
7.5	24 x 10 <sup>6</sup>
10	24 x 10 <sup>6</sup>
10 to 30	14 x 10 <sup>6</sup>

**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 must not include human use.

**Roentgen:** The unit of exposure to X or gamma radiation. One roentgen is the exposure corresponding to ionization in air of one electrostatic unit of charge of either sign in 0.001293 gram of air.

**RSC:** See Radiation Safety Committee.

**RSO:** See Radiation Safety Officer.

**RUA:** See Radiation Use Authorization.

## S

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**Sealed Source:** Any radioactive material that is permanently encapsulated in such manner that the radioactive material will not be released under the most severe conditions likely to be encountered by the source.

**Source Material:** Uranium or thorium, or any combination thereof, in any physical or chemical form, except special nuclear material and ores which contain by weight less than one-twentieth of one percent (0.05 percent) of uranium, thorium, or any combination thereof.

**Special Nuclear Material:** (1) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, or (2) any material artificially enriched by any of the foregoing, but does not include source material.

**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 the quantity of radioactive material present.

## U

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**UCR:** University of California, Riverside.

**Uncontrolled Area:** Any area that is not a controlled area.