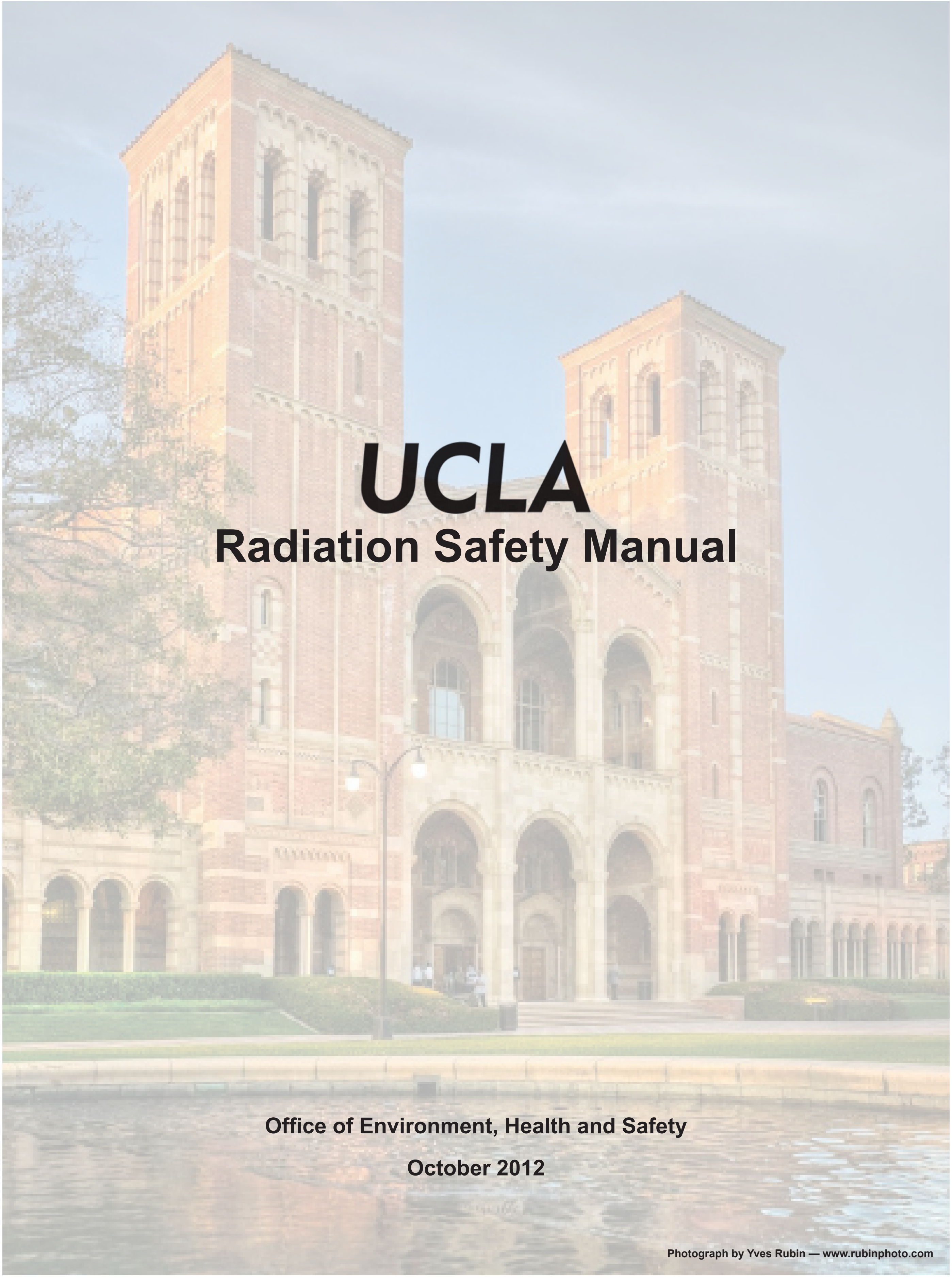

UCLA
Radiation Safety Manual

Office of Environment, Health and Safety

October 2012

Photograph by Yves Rubin — www.rubinphoto.com

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Table of Contents

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Chapter 1: Introduction

Purpose

The State of California Department of Public Health (CDPH) – Radiologic Health Branch (RHB) has granted UCLA the authority to work with radioactive materials under a "Type A" broad scope license issued to the Regents of the University of California. State regulations stipulate that this license be administered by a Radiation Safety Committee whose members are knowledgeable and experienced in radioactive material use and radiation safety.

At UCLA, the Office of the Radiation Safety Committees (ORSC) provides administrative support for the Radiation Safety Committee (RSC) and its subcommittees: the Academic Radiation Safety Committee (ARSC), the Clinical Operations Radiation Safety Committee (CORSC), the Medical Radiation Safety Committee (MRSC), and the Radioactive Drug Research Committee (RDRC). The ORSC is under the Office of Research Administration (ORA) which provides the campus with professional guidance and administrative support for all sponsored research activities. More information regarding the ORSC and the Committees may be found at the ORSC website (*http://ora.research.ucla.edu/ORSC/Pages/AboutORSC.aspx*). The chairperson and members of the Radiation Safety Committee are appointed by the Vice Chancellor of Research. Regulations also require the appointment of a qualified Radiation Safety Officer (RSO) and the participation of management at a high level. In keeping with campus Policy 811, (*http://www.adminpolicies.ucla.edu/app/Default.aspx?&id=811*), the Chancellor requires vice chancellors and deans to establish safe working environments and to enforce specific elements of the Radiation Safety Program within their areas of operation.

The Radiation Safety Manual is a formal statement of policies and procedures pertaining to radiation safety and is reviewed and evaluated on a frequent basis to ensure effectiveness and compliance with current regulations. The manual also outlines operational guidelines and program specific requirements for the use of radiation in a research setting. This version of the Radiation Safety Manual replaces all previous versions that have been distributed to persons who are engaged in research with radioactive material and/or radiation-producing machines. A copy of this manual must be present in the laboratory of each research group that uses radiation at UCLA and individuals working within the laboratory should be familiar with its contents.

REGULATORY REFERENCES

Federal and state regulating bodies have developed and implemented policies used to control the use of radiation in the United States. The Nuclear Regulatory Commission (NRC) operates on the federal level and is responsible for ensuring that the public and environment are protected from unnecessary radiation exposure from certain types of radioactive materials. As an "agreement state", the state of California has assumed regulatory authority from the NRC to license and regulate these materials.

The U.S. Food and Drug Administration (FDA) sets criteria for machine-produced sources of radiation such as x-rays. However, the state of California performs inspections, controls radiation-producing machine inventory, and regulates the use of these devices. The CDPH – RHB acts on behalf of the NRC and FDA to ensure compliance with regulations and that radioactive materials and radiation-producing machines are used safely in the state.

Requirements for the use of radioactive material are primarily found in the following regulations:

- Title 10, Code of Federal Regulations (CFR), Part 20: *Standards for Protection Against Radiation (http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/)*
- Title 49, CFR, Parts 171, 172, & 173 *(http://www.access.gpo.gov)*
- Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapters 4.0, 4.5, & 4.6 *(http://ccr.oal.ca.gov)*

Authority and Responsibilities

While the Chancellor, Vice Chancellors, and Deans are responsible for ensuring that operations in their areas comply with regulatory requirements, direct supervising responsibility of requirements specified in this manual, and other campus radiation safety policies, rests with the Principal Investigator (PI) to whom the Radiation Safety Committee grants a specific Radioactive Materials Permit and/or Radiation-Producing Machines Permit. Ultimately, it is the responsibility of each individual user to maintain safe work practices and a safe working environment.

PRINCIPAL INVESTIGATORS

The Principal Investigator of a Radioactive Materials Permit and/or Radiation-Producing Machine Permit is responsible for the safety of individual users working with radiation under their permit. The PI may delegate safety related tasks, as appropriate, but retains responsibility for ensuring that all radiation safety-related duties are adequately performed. These duties include, but are not limited to:

1. Knowing and complying with applicable regulations and policies for the type of radiation work conducted under the permit.
2. Providing all laboratory staff with documented training, including proper operating procedures, use and location of safety equipment, and applicable regulations and policies as appropriate for the scope of the work.
3. Ensuring the availability, maintenance, and proper use of all appropriate personal protective equipment (PPE) in accordance with campus Policy 905 (*http://www.adminpolicies.ucla.edu/app/Default.aspx?&id=905*).
4. Immediately notifying the Office of Environment, Health & Safety (EH&S) by calling the EH&S Hotline at 310-825-9797 in the event of a serious injury, significant spill, or other emergency.
5. Ensuring that all radioactive materials and radiation-producing machines are kept secured from access by unauthorized individuals.

RADIOACTIVE MATERIAL USERS AND RADIATION-PRODUCING MACHINE OPERATORS

Each individual who works with radiation is responsible for following established safety and operating guidelines to support a safe work environment for themselves, other workers, and members of the public. Responsibilities include, but are not limited to:

1. Reviewing and following the requirements of the Radiation Safety Manual, laboratory standard operating procedures, and the Radioactive Materials or Radiation-Producing Machine Permit.

2. Reporting unsafe conditions and accidents to the PI, Laboratory Supervisor, or Radiation Safety Supervisor in a timely manner. All personnel working with potentially hazardous materials are encouraged to report (anonymously, if preferred) any concerns about unsafe work conditions to the EH&S Hotline at 310-825-9797.

3. Reviewing and understanding associated safety hazards before beginning work.

4. Meeting the requirements of the campus personal protective equipment (PPE) policy (UCLA Policy 905) (*http://www.adminpolicies.ucla.edu/app/Default.aspx?&id=905*).

RADIATION SAFETY COMMITTEE

The Radiation Safety Committee is responsible for maintaining UCLA personnel radiation exposures as low as reasonably achievable (ALARA) and overseeing all activities at UCLA involving the use of radioactive materials and radiation-producing machines. The Committee develops campus policy concerning radiation safety.

The Committee chairperson and members are selected from faculty and staff who are knowledgeable in radiation safety and the use of radioactive material and radiation-producing machines. The term of membership is one year and is renewable. The Committee has the authority to evaluate and authorize research, development, educational and clinical uses of radioactive material and radiation-producing machines and may suspend or revoke authorization for the use of radioactive material or the operation of a radiation-producing machine as needed to ensure safety and regulatory compliance.

OFFICE OF ENVIRONMENT, HEALTH & SAFETY

The Office of Environment, Health & Safety (EH&S) is responsible for ensuring that all UCLA facilities are operated in a safe manner and comply with the requirements of governmental agencies and University of California policies. EH&S provides technical guidance and services to personnel at all levels of responsibility on matters pertaining to laboratory safety, industrial hygiene, fire safety, and work safety to ensure a safe working environment at UCLA through the implementation of various safety divisions. The Director of EH&S serves on a number of campus safety committees and has the authority to order the cessation of activities in cases of life safety matters or immediate danger to life or health until the hazardous condition is abated.

RADIATION SAFETY PROGRAM AND RADIATION SAFETY OFFICER (RSO)

EH&S has implemented a Radiation Safety Program that manages the use of radioactive material and radiation-producing machines on campus which is managed by the Radiation Safety Officer as required by regulation, who operates under the oversight of the EH&S Director. The RSO is a member of EH&S and is designated by name and position as a license condition and, by regulation, serves as a member of the Radiation Safety Committee. The Radiation Safety Program supports and reviews the operational aspects of radiation safety on a day-to-day basis and provides technical guidance and information to the Committee. EH&S responsibilities include, but are not limited to:

1. Informing PIs/Radiation Safety Supervisors of all health and safety requirements pertaining to radiation related work and assisting with the selection of appropriate safety controls, including laboratory and other workplace practices, engineering controls, training, etc.
2. Supporting safety through the review of operational procedures, by performing periodic inspections, and by supplying safety training.
3. Assisting with the development and implementation of radiation use policies and practices.
4. Immediately taking steps to abate hazards that may pose a risk to life or safety upon discovery of such hazards.
5. Performing hazard assessments, upon request.
6. Maintaining area and personnel radiation exposure monitoring records.
7. Having working knowledge of current radiation safety rules and regulations, training, and reporting requirements.
8. Regulatory functions such as the administration of the Radioactive Materials Permit and Radiation-Producing Machine Permit programs, survey and audit functions, and assuring compliance with federal, state, and local radiation control regulations.
9. Reviewing plans for installation of engineering controls and new facility construction/renovation, as requested or required.
10. Educational functions to support and train radiation users as well as to provide community outreach activities.
11. Service functions to meet client needs such as radioactive waste disposal, instrument calibration, and emergency response.

These layers of responsibility detail the need for staff at all levels to share in achieving and maintaining a culture of safety when working with ionizing radiation. The remaining chapters of this manual are organized by specialty subject and detail specific guidelines and requirements.

Chapter 2: Radioactive Materials Permits

Introduction

Radioactive isotopes are used in many capacities at UCLA and must be managed safely and legally. The EH&S Radiation Safety Program, under direction of the Radiation Safety Committee, issues individual Radioactive Materials Permits to specific Principal Investigators (PIs) to effectively manage the receipt, handling, and disposal of radioactive material on campus. Detailed information on the permitting process and requirements are included in this chapter.

Planning for the Use of Radioactive Material

Each project involving the use of radioactive material must be planned by the PI to ensure that research activities are conducted safely and are compliant with all pertinent laws, regulations, policies, and procedures. Planning ensures the safety of those handling radioactive material directly, peripheral non-radiation workers, and members of the public by maintaining radiation exposures at levels as low as reasonably achievable (ALARA). Inadequate planning may result in unwarranted radiation exposure, contamination issues, or other serious safety problems.

When planning for the use of radioactive material in an experiment or project, it is important to consider many factors, including:

- Radioactive material quantities and chemical forms
- Laboratory layout
- Safety controls
- Personnel training

RADIOACTIVE MATERIAL QUANTITIES AND CHEMICAL FORMS

Radioisotopes are approved for use by activity and chemical form. The radioisotope quantities requested by a PI for a project should be limited to only the quantities needed. Requesting approval for the minimum quantity of radioisotope required for a project will reduce exposure to personnel, minimize radioactive waste, and adhere to the principal of ALARA. Limiting the amount of radioisotope is especially important for projects in which volatile chemical forms may be used, and radioactive material has the potential to be released into the environment.

LABORATORY LAYOUT

The PI and Radiation Safety Supervisor should plan the layout of the main radioactive material work area within a radioactive material laboratory to minimize exposure to laboratory personnel and to control potential contamination. Items to consider are: the location of the radioactive material work area and its proximity to peripheral laboratory workers, the size of the radioactive material work area, and the location of essential equipment such as fume hoods, centrifuges, emergency showers, spill kits, radioactive stock vial and waste storage locations.

SAFETY CONTROLS

Administrative Controls

All authorized laboratory groups and associated personnel must comply with campus and EH&S policies to ensure the protection of the health and safety of their individual work groups, campus personnel, the general public, and the environment. Laboratory specific operating and safety procedures must ensure that radioactive material is handled in a safe manner.

Engineering Controls

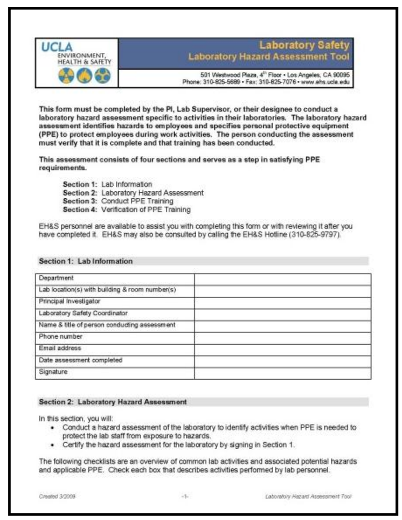
Depending on the scope of radioactive material use, engineered physical controls may be required prior to approval of the project or research. Engineered controls include shielding to reduce exposure to penetrating radiation and fume hoods or glove boxes to mitigate contamination and prevent exposure to airborne radioisotopes.

Environmental Considerations

Release of hazardous materials to the environment, including radioactive material, is strictly regulated. Uncontrolled release, even accidental, is a violation of university policy, the UCLA radioactive materials license, federal and state regulations, and the principle of ALARA. All radioactive material must be managed in such a way as to ensure that inventory is properly maintained and that all radioactive waste, even rinse water, is collected appropriately.

PERSONNEL TRAINING

Adequate training of individuals who are directly and indirectly involved with radiation and radioactive material handling is foundational to a strong radiation safety program. At UCLA, radiation safety training is accomplished through a partnership between EH&S, the PI, the Radiation Safety Supervisor, and laboratory personnel. Effective radiation safety training has two primary elements: initial training and continuing training. Additionally, periodic performance-based review of how radioactive material is used by the research group is critical. Any change to existing standard operating procedures (SOP) requires retraining of applicable personnel.



UCLA ENVIRONMENT, HEALTH & SAFETY

Laboratory Safety
Laboratory Hazard Assessment Tool

501 Westwood Plaza, 4th Floor • Los Angeles, CA 90095
Phone: 310-825-5689 • Fax: 310-825-7076 • www.ehs.ucla.edu

This form must be completed by the PI, Lab Supervisor, or their designee to conduct a laboratory hazard assessment specific to activities in their laboratories. The laboratory hazard assessment identifies hazards to employees and specifies personal protective equipment (PPE) to protect employees during work activities. The person conducting the assessment must verify that it is complete and that training has been conducted.

This assessment consists of four sections and serves as a step in satisfying PPE requirements.

Section 1: Lab Information
Section 2: Laboratory Hazard Assessment
Section 3: Conduct PPE Training
Section 4: Verification of PPE Training

EH&S personnel are available to assist you with completing this form or with reviewing it after you have completed it. EH&S may also be consulted by calling the EH&S Hotline (310-825-9797).

Section 1: Lab Information

Department	
Lab location(s) with building & room number(s)	
Principal Investigator	
Laboratory Safety Coordinator	
Name & title of person conducting assessment	
Phone number	
Email address	
Date assessment completed	
Signature	

Section 2: Laboratory Hazard Assessment

In this section, you will:
- Conduct a hazard assessment of the laboratory to identify activities when PPE is needed to protect the lab staff from exposure to hazards.
- Certify the hazard assessment for the laboratory by signing in Section 1.

The following checklists are an overview of common lab activities and associated potential hazards and applicable PPE. Check each box that describes activities performed by lab personnel.

Created 3/2009 -1- *Laboratory Hazard Assessment Tool*

Hazard awareness and personal protective equipment (PPE) training is also essential for all laboratory staff, whether individuals are directly handling radioactive material or if they are working peripherally in a commissioned laboratory. Annual completion of the Laboratory Hazard Assessment Tool (http://lsm.ehs.ucla.edu) is required for all hazardous materials use laboratories and includes a personal protective equipment training documentation form. This form may be found on the EH&S website (www.ehs.ucla.edu). Please refer to *Chapter 4: Training* for specific training requirements.

Obtaining a Radioactive Materials Permit

APPLICATION PROCESS

Each PI wishing to apply for a Radioactive Materials Permit must complete a Radioactive Materials Permit Application *(see www.ehs.ucla.edu)*. In addition, a Statement of Training and Experience attachment must be completed in full. If radioactive material will be used in animals, the Office of Animal Research Oversight (OARO) must be notified and an Animal Research Committee (ARC) protocol will be required. It is important to note that Office of Animal Research Oversight approval of an ARC protocol does not authorize the use of radioisotopes in/on animals. Radioactive material may only be used after the Radiation Safety Office and the Radiation Safety Committee have reviewed and approved its use. Application materials and an instruction guide are available on the EH&S website (*www.ehs.ucla.edu)* or by emailing EH&S at *radiationsafety@ehs.ucla.edu*. Once completed and signed by both the PI and Department Chairperson, applications should be submitted to EH&S. The application and all supporting documentation (e.g., radioactive material handling procedures), may be faxed, scanned and sent via e-mail, or sent via regular or campus mail.

EH&S will assign a unique permit number, termed a Laboratory Authorization (LA) number, and a health physicist will complete the initial application review. Any requests for further information will be facilitated by the assigned health physicist. The need for personnel or environmental monitoring, detection equipment, training, fume hood or glove box use, and other special conditions is determined during the review process. A Safety Index value will also be assigned at the time of the health physicist's review. The Safety Index is a calculated value employed by EH&S to assess the risks associated with the laboratory use of specific radioisotopes. The numerical value of the Safety Index determines the extent to which the Radiation Safety Committee becomes involved in the review of radioactive materials permits and their amendments, as well as the frequency and level of inspection by EH&S.

Commissioning of Radioactive Material Use Laboratories

Prior to final permit approval, the EH&S Radiation Safety Program will inspect the laboratory space intended for radioactive material use and commission the laboratory. All necessary safety equipment, including appropriate waste containers, secondary containment, radiation detection instruments, and shielding (if applicable) must be procured prior to the commissioning survey. EH&S has a limited number of recycled waste containers available for use. Please contact EH&S at *radiationsafety@ehs.ucla.edu* for more information.

After permit approval, if the laboratory group wishes to add additional radioactive material use laboratories, the rooms must first be commissioned by the EH&S Radiation Safety Office. The office must be contacted at a minimum of two weeks before the space needs to be approved for use to schedule a commissioning survey.

Once commissioned, a laboratory may not be released as a non-radioactive material use area until a clearance survey has been conducted by EH&S Radiation Safety staff.

After being reviewed and approved by EH&S, application materials are forwarded to a member of the Radiation Safety Committee. The Committee member will indicate approval by signing the Radioactive Materials Permit posting. The posting lists all authorized radioisotopes, use limitations, radioisotope quantity limits, laboratory use locations, special conditions, and animal or human use research protocols, as appropriate. The assigned health physicist will then meet with the PI and Radiation Safety Supervisor to review the Radiation Safety Manual and pertinent UCLA and radiation safety policies. Points of discussion will involve the radioisotope acquisition process, laboratory surveillance requirements, waste management, and personal protective equipment selection. The Radioactive Materials Permit posting and a California Department of Public Health (CDPH) Notice to Employees form will be provided at this meeting and must be posted in a conspicuous location within the laboratory. All laboratory personnel should review these documents for familiarity.

When all radioactive material use laboratory space has been commissioned and the Radioactive Materials Permit has been approved by a Committee member, the permit is considered to be active. The responsible health physicist for the permit will notify the PI and Radiation Safety Supervisor when the permit is active and radioactive material use may commence.

Radioactive Material Use Laboratory Guidelines

- All radioactive material use laboratories ***MUST*** be approved for use by the Radiation Safety Office. ***NO*** radioactive material work may be performed in a non-commissioned space.
- Radioactive material use laboratories must be cleared by the Radiation Safety Office prior to any remodel or release for non-radioactive material use.

RADIOACTIVE MATERIALS PERMIT AUTHORIZATION PERIOD

Each Radioactive Materials Permit is approved for a period of four years. Prior to the Radioactive Materials Permit expiration date, EH&S will send a permit renewal notice and renewal form to the PI. The purpose of the permit renewal form is to determine the current status of radioactive material use by the group. If the PI wishes to extend the Radioactive Materials Permit authorization period, all relevant information specified on the renewal form must be reviewed. Any requests for permit revision should be indicated on the form, including changes to personnel, radioisotopes and their uses, laboratory locations, or detection instruments. The completed form must be signed by both the PI and the Department Chairperson and returned to EH&S by the renewal due date.

AMENDMENT OF RADIOACTIVE MATERIALS PERMIT

A Radioactive Materials Permit may be amended before the expiration date. The PI may apply for such changes through their assigned health physicist. Requests must include sufficient information to enable an evaluation by EH&S and, in some cases, the Radiation Safety Committee.

Committee approval is not required for a Radioactive Materials Permit amendment if the documents supplied by the PI, and audits by EH&S, show no significant operational problems or changes. However, in some cases, the Radiation Safety Officer may think it necessary to refer Radioactive Materials Permit amendments to the Committee for guidance or approval.
Radioactive Materials Permit amendments are necessary for the following requests:

- Increase in shipment or possession limits of approved radioisotopes

- Addition or deletion of new radioisotopes and/or chemical forms
- Changes in experimental procedures (including changes in activities used per experiment)
- Addition or deletion of animal use research protocols
- Radioactive material use room clearances or commissionings
- Personnel changes
- Instrument changes

Termination or Transfer of a Radioactive Materials Permit

EH&S must be informed of any intention to terminate a Radioactive Materials Permit, release a radioactive material use laboratory for general use, or remodel a radioactive material use area. EH&S will perform a clearance survey of the laboratory space prior to approval. Abandonment, relocation, or remodeling of a commissioned radioactive material use laboratory is prohibited without written approval from EH&S. Abandoning a radiation use area without EH&S approval is a violation of EH&S policy and may potentially subject the PI and/or department to costly clean up fees.

CLEARANCE OF RADIOACTIVE MATERIAL USE LABORATORIES OR EQUIPMENT

If a PI wishes to terminate or transfer their Radioactive Materials Permit, EH&S must be contacted well ahead of any laboratory transfers or remodeling of the commissioned laboratory space. EH&S will schedule a time with the PI or Radiation Safety Supervisor to perform a clearance survey. Additionally, equipment and laboratory furniture that has been used or stored in a radioactive material use laboratory or work area may not be transferred to a general or non-radioactive material use area without final clearance by the EH&S Radiation Safety Office.

Prior to the clearance survey, the PI (or qualified designee) may be required to do one or more of the following:

- Return all remaining radioisotopes and radioactive waste to EH&S for disposal.
- Ensure that all personnel assigned to the Radioactive Materials Permit have completed their required bioassay measurements and returned their dosimetry to EH&S, as applicable.
- Perform a final radiation survey of all laboratory areas to ensure that no contamination is present and report these findings to EH&S.

When EH&S has completed the laboratory clearance survey and approves of the release of the area for general use, a final clearance report will be submitted to the PI.

Clearance of Equipment Containing Radioactive Internal Sources (Liquid Scintillation Counters, Gas Chromatographs, Static Eliminators)

Special precautions must be taken for certain equipment such as liquid scintillation counters, gas chromatographs (electron capture detectors), and static eliminators. These instruments are generally licensed and contain radioactive sources that must be removed by the vendor or by EH&S prior to disposal. EH&S must be contacted to ensure proper disposal or transfer of the installed radioactive material. If the manufacturer of the equipment will be removing the installed sources, EH&S should be informed prior to the source removal.

Chapter 3: Radiation-Producing Machines Permit

Introduction

A radiation-producing machine is any device (generally high voltage) that, during operation, can generate or emit ionizing radiation. This definition does not include machines that produce ionizing radiation solely by the use of radioactive material. Over 300 radiation-producing machines are operated at UCLA, both on and off-campus. All radiation-producing machines are subject to California state laws and regulations. EH&S is responsible for ensuring compliance with these laws and for controlling the use of these machines.

Examples of radiation-producing machines include x-ray machines used in diffraction and fluorescence analyses, electron microscopy, cyclotrons, and other particle accelerators. This chapter does not apply to radiation-producing machines to be used in the healing arts (e.g., use of x-rays in medicine, dentistry, osteopathy, chiropractic, and podiatry).

Planning for the Use of Radiation-Producing Machines

Each PI is required to develop, document, and implement radiation protection measures in their laboratories that will ensure that all radiation-producing machine related procedures are conducted safely and are compliant with all pertinent laws, regulations, policies, and procedures. Additionally, the PI must use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as reasonably achievable (ALARA).

FACILITY DESIGN

It is important to properly plan the location where the radiation-producing machine will be used and ensure that the installation of the unit is designed with safety and compliance in mind. Pre-operational measurements and evaluation of installed shielding and operating procedures may be necessary before routine use of the machine can be authorized.

SHIELDING CONSIDERATIONS

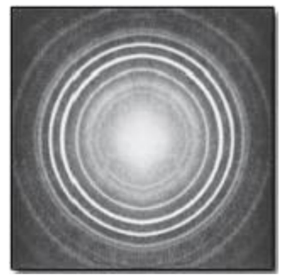
Analytical machines such as x-ray diffraction, x-ray fluorescence, electron microscopes, and cabinet units typically have integral shielding and generally require no additional shielding. Some of these machines utilize an intense x-ray beam with primary beam exposure rates of up to 10,000 roentgen(R)/min. The PI must ensure that these machines are operated in accordance with the manufacturer's specifications and specific safe operating procedures.

RADIATION-PRODUCING MACHINE OPERATOR TRAINING

Only trained and authorized personnel may operate radiation-producing machines. Users must receive initial training and successfully complete an examination prior to using x-ray equipment. Several initial training courses are offered by EH&S, depending on the type of radiation-producing machine use. The “X-ray Diffraction Safety Training” course is required for individuals who will be operating radiation-producing machines for analytical purposes. Linear accelerator and cabinet x-ray users should contact EH&S for training and examination materials prior to using the equipment.

Authorized PIs and laboratory supervisors are required to provide program specific training to their staff.

Figure 3.1 – X-ray Diffraction Pattern



This training should include:
Review of radiation protection tenets of time, distance, and shielding

- UCLA and EH&S policies and procedures
- California Department of Public Health (CDPH) regulatory requirements
- Dosimetry requirements, if applicable
- Site-specific information, such as safe operating procedures for x-ray machines, safe use of x-ray machines in the laboratory, and policies and procedures related to x-ray machines used for experiments or for research purposes

PIs must ensure that their staff members are trained on the operating procedures for their equipment and must address all hazards associated with their specific laboratory, whether the staff member will be working directly with radiation-producing machines or peripherally in the laboratory environment. Please refer to *Chapter 4: Training* for specific training requirements.

Radiation-Producing Machine Registration

Radiation-producing machines must be registered with the CDPH within 30 days of installation. In accordance with existing regulations, they must also be renewed on a biennial basis. EH&S performs all required machine registration functions. The PI must supply registration information, or an x-ray machine status change, to EH&S in a timely manner. This can best be accomplished by contacting EH&S, completing the appropriate form, and providing the necessary details of the installation (i.e., make, model, control serial number, location, and operating procedures). Once EH&S is in receipt of this information, the appropriate registration paperwork is submitted to the CDPH.

SPECIAL FACILITIES

The permitting and survey requirements for facilities containing radiation-producing machines that can produce significant levels of radiation (e.g., cyclotrons, Tokamak units) are implemented on a case-by-case basis and may require prior approval from the CDPH. EH&S must be contacted immediately if these types of machines are to be acquired.

Obtaining a Radiation-Producing Machine Permit

APPLICATION PROCESS

In addition to State registration requirements, operation of any x-ray machine at UCLA must also be authorized by EH&S. All x-ray machines are required to have a current Radiation-Producing Machine Permit issued by EH&S before they can be operated. Each PI who wishes to apply for a Radiation-Producing Machine Permit must complete a Radiation-Producing Machine Permit Application. These applications are available at the EH&S website (*www.ehs.ucla.edu)* or through request by e-mail to *radiationsafety@ehs.ucla.edu*. Once completed, the application must be submitted with the laboratory's safe operating procedures, manufacturer's operating procedures, and all other pertinent information to EH&S for review and approval by fax, email, or campus mail.

EH&S will assign a unique permit number, called a Machine Authorization (MA) number, to the application and a health physicist will complete the initial application review. Any requests for further information will be facilitated by the assigned health physicist. The need for personnel or area monitoring, training, or specific engineering controls is determined during the review process, along with any other special conditions.

Commissioning of Radiation-Producing Machine Rooms

Prior to final permit approval, EH&S will inspect the space intended to contain the radiation-producing machine and commission the room. All necessary safety equipment, including appropriate shielding (if necessary), interlock system(s), emergency stop(s), equipment postings, caution signs, etc. must be procured prior to the commissioning survey. Please contact EH&S for more information at *radiationsafety@ehs.ucla.edu*.

Once commissioned, a laboratory may not be released as a non-radiation use area until a clearance survey has been conducted by the EH&S Radiation Safety Office and all signage has been removed.

After the Radiation-Producing Machine Permit is reviewed and approved by EH&S, the application materials are forwarded to a member of the Radiation Safety Committee. The Committee member will indicate approval by signing the Radiation-Producing Machine Permit posting. The posting lists all authorized machines, use limitations, machine locations, and special conditions, as appropriate. The assigned health physicist will then meet with the PI and Radiation Safety Supervisor to review the Radiation Safety Manual and all pertinent UCLA and EH&S policies.

The Radiation-Producing Machine Permit posting and a CDPH Notice to Employees form will be provided at this meeting and must be posted in a conspicuous location within the laboratory. All laboratory personnel should review these documents for familiarity. After this meeting, the PI is authorized to use radiation-producing machines based on the conditions listed on their permit.

Radiation-Producing Machine Facility Guidelines

- All radiation-producing machine use areas ***MUST*** be approved for use by EH&S. ***NO*** radiation-producing machine may be used in a non-commissioned space.
- Radiation-producing machine use laboratories must be cleared by EH&S prior to permit termination or release of radiation-producing machines.

RADIATION-PRODUCING MACHINE PERMIT AUTHORIZATION PERIOD

Each Radiation-Producing Machine Permit is approved for a period of three years. Prior to the permit's expiration date, EH&S will send a renewal notice and renewal form to the PI. The purpose of the Radiation-Producing Machine Permit renewal form is to determine the current status of x-ray use by the group. If the PI wishes to extend the permit authorization period, all relevant information specified on the renewal form must be reviewed. Any requests for permit revision should be indicated on the form, including changes to personnel, x-ray equipment and their uses, or laboratory locations. The completed form must be signed by the PI and returned to EH&S by the renewal due date.

AMENDMENT OF RADIATION-PRODUCING MACHINE PERMITS

A Radiation-Producing Machine Permit may be amended before the expiration date. The PI applies for such changes through their designated health physicist via phone, e-mail, or written mail. Requests must include sufficient information to enable an evaluation by EH&S and, in some cases, the Radiation Safety Committee.

Radiation Safety Committee approval is not required for a Radiation-Producing Machine Permit amendment if the documents supplied by the PI, and audits by EH&S, show no significant operational problems or changes. However, in some cases, the Radiation Safety Officer may feel it necessary to refer permit amendments to the Committee for guidance or approval.

Radiation-Producing Machine Permit amendments are necessary for the following requests:

- Addition or deletion of new radiation-producing machines
- Changes in radiation-producing machine locations
- Changes in radiation-producing machine uses
- Personnel changes

Termination of a Radiation-Producing Machine Permit

The EH&S Radiation Safety Program must be informed of any intention to terminate a Radiation-Producing Machine Permit or of the release or disposal of radiation-producing machines. EH&S will perform a clearance survey of the laboratory space prior to approval to ensure all non-applicable signs and postings are removed. Abandonment, relocation, or remodeling of a commissioned space is prohibited without written approval from EH&S. Abandoning a commissioned space without EH&S approval is a violation of EH&S policy and may potentially subject the PI and/or department to costly fees. (*See Chapter 12: Compliance)* If you wish to terminate your Radiation-Producing Machine Permit, contact your assigned health physicist directly well-ahead of any laboratory transfers or remodeling of commissioned laboratory space.

Guidance for Disposal of Radiation-Producing Machines

The final disposition of radiation-producing machines must be reported to EH&S. Upon receipt of proper documentation, EH&S will remove the machine(s) from the machine registration inventory with the CDPH. **Proper and credible** documentation (e.g. service reports evidencing disassembly or disabling of the machine, photos, sales contract, etc.) must clearly demonstrate the disposition of the radiation-producing machine. Continued registration is required for radiation-producing machines that are not used but are physically present in a facility or are in storage.

NOTE: This guidance does not apply to particle accelerators.

Regarding Disposal

Although there is no residual radiation, there may be environmental restrictions on what components may go into a land-fill after disassembly, such as chemical contaminants in cooling oil. Any hazardous materials should be disposed of by appropriately licensed companies or authorities.

- The registrant should follow the disposal instructions provided by the manufacturer in the product manual, and/or contact the manufacturer for information and guidance.
- When manufacturer guidance is not available:
    - ✓ Radiation-producing machine components may be returned to a commercial x-ray machine assembler or vendor; or
    - ✓ The radiation-producing machine may be totally disabled and the components sold as scrap metal or disposed of according to the state of California’s environmental requirements; or
    - ✓ The radiation-producing machine may be rendered non-functional by disassembly and/or component removal such that repair and use may not be readily affected.

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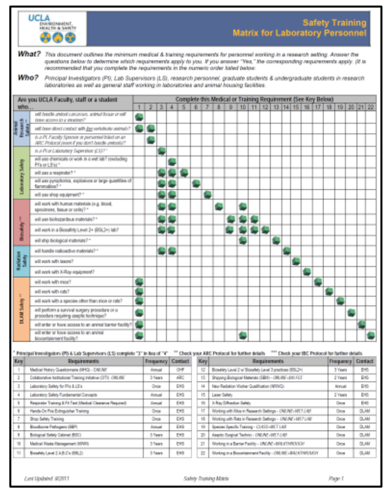
Chapter 4: Training

Introduction

The management of an organization using radioactive material and/or radiation-producing machines must ensure that its radiation workers are trained in radiation protection as a component of their job proficiencies. The use of radioactive material or radiation-producing machines is not without risk and may result in radiation exposure to faculty, students, staff employees, and visitors. While the levels of exposure are maintained within safe and legal limits, proper training equips radiation workers with the knowledge and skills necessary to maintain radiation exposure as low as reasonably achievable (ALARA) for themselves and visitors under their supervision. Also, radiation safety training informs individuals of the associated risks involved with exposure to ionizing radiation.

EH&S relies on the direct support of principal investigators (PI), laboratory supervisors, and radiation safety supervisors to identify those individuals who require training, based on the type of work being performed. A Lab Safety Training Matrix (see Figure 4.1) is available on the EH&S website (www.ehs.ucla.edu) to aid in the determination of training requirements. Ultimately it is the PI's primary responsibility to ensure laboratories meet initial and continuing training requirements. This chapter outlines the training guidelines and procedures for radioactive material and radiation-producing machine users.

Figure 4.1 – Training Matrix



Initial Training Requirements

OCCUPATIONAL RADIATION WORKERS

Individuals who directly handle radioactive material or radiation-producing machines are referred to as occupational radiation workers and are required to complete radiation safety training; this training must be documented by EH&S. EH&S provides initial radiation safety training courses that introduce basic radiation safety principles, techniques, and requirements along with supplemental documents containing relevant safety and compliance information. At the conclusion of the training session, an examination is administered to document the success of the training. Only those who successfully pass the examination will be permitted to work with radioactive material or radiation-producing machines.

Initial radiation safety training must be supplemented by laboratory specific training and should be documented. The PI is responsible for ensuring that ongoing training is also conducted when protocols or laboratory conditions have changed. Laboratory specific training should cover, but is not limited to, the following:

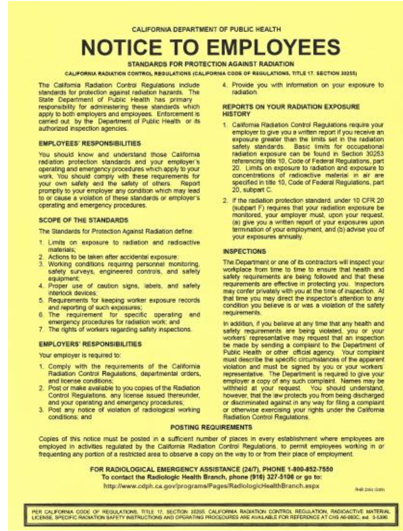
- Where radioactive material and/or radiation-producing machines are used and stored in the laboratory
- California Department of Public Health – Notice to Employees and permit postings
- The location of standard operating protocols and emergency procedures

- The location of safety equipment, personal protective equipment, and spill kits
- Laboratory security

Personnel training will be evaluated during routine laboratory inspections by the inclusion of performance-based questions. This element of the inspection will be used to determine if training levels are sufficient to maintain compliance. If compliance issues are found during routine inspections, EH&S may require additional training sessions.

EH&S categorizes occupational workers in the research setting into two general categories, based on the type of radiation being used: *Radioactive Material Users* and *Radiation-Producing Machine Operators*. Each type of worker must complete radiation safety training pertinent to the radiation work that they will be performing.

Figure 4.2 – Notice to Employees Posting



CALIFORNIA DEPARTMENT OF PUBLIC HEALTH

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION

CALIFORNIA RADIATION CONTROL REGULATIONS (CALIFORNIA CODE OF REGULATIONS, TITLE 17, SECTION 30255)

The California Radiation Control Regulations include standards for protection against radiation hazards. The State Department of Public Health has primary responsibility for administering these standards which apply to both employers and employees. Enforcement is carried out by the Department of Public Health or its authorized inspection agencies.

EMPLOYEES' RESPONSIBILITIES

You should know and understand those California radiation protection standards and your employer's operating and emergency procedures which apply to your work. You should comply with these requirements for your own safety and the safety of others. Report promptly to your employer any condition which may lead to or cause a violation of these standards or employer's operating and emergency procedures.

SCOPE OF THE STANDARDS

The Standards for Protection Against Radiation define:

1. Limits on exposure to radiation and radioactive materials;
2. Actions to be taken after accidental exposure;
3. Working conditions requiring personnel monitoring, safety surveys, engineered controls, and safety equipment;
4. Proper use of caution signs, labels, and safety interlock devices;
5. Requirements for keeping worker exposure records and reporting of such exposures;
6. The requirement for specific operating and emergency procedures for radiation work; and
7. The rights of workers regarding safety inspections.

EMPLOYERS' RESPONSIBILITIES

Your employer is required to:

1. Comply with the requirements of the California Radiation Control Regulations, departmental orders, and license conditions;
2. Post or make available to you copies of the Radiation Control Regulations, any license issued thereunder, and your operating and emergency procedures;
3. Post any notice of violation of radiological working conditions; and
4. Provide you with information on your exposure to radiation.

REPORTS ON YOUR RADIATION EXPOSURE HISTORY

1. California Radiation Control Regulations require your employer to give you a written report if you receive an exposure greater than the limits set in the radiation safety standards. Basic limits for occupational radiation exposure can be found in Section 30253 referencing title 10, Code of Federal Regulations, part 20. Limits on exposure to radiation and exposure to concentrations of radioactive material in air are specified in title 10, Code of Federal Regulations, part 20, subpart C.
2. If the radiation protection standard, under 10 CFR 20 (subpart F) requires that your radiation exposure be monitored, your employer must, upon your request, (a) give you a written report of your exposures upon termination of your employment, and (b) advise you of your exposures annually.

INSPECTIONS

The Department or one of its contractors will inspect your workplace from time to time to ensure that health and safety requirements are being followed and that these requirements are effective in protecting you. Inspectors may confer privately with you at the time of inspection. At that time you may direct the inspector's attention to any condition you believe is or was a violation of the safety requirements.

In addition, if you believe at any time that any health and safety requirements are being violated, you or your workers' representative may request that an inspection be made by sending a complaint to the Department of Public Health or other official agency. Your complaint must describe the specific circumstances of the apparent violation and must be signed by you or your workers' representative. The Department is required to give your employer a copy of any such complaint. Names may be withheld at your request. You should understand, however, that the law protects you from being discharged or discriminated against in any way for filing a complaint or otherwise exercising your rights under the California Radiation Control Regulations.

POSTING REQUIREMENTS

Copies of this notice must be posted in a sufficient number of places in every establishment where employees are employed in activities regulated by the California Radiation Control Regulations, to permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.

FOR RADIOLOGICAL EMERGENCY ASSISTANCE (24/7), PHONE 1-800-852-7550
To contact the Radiologic Health Branch, phone (916) 327-5106 or go to:
http://www.cdph.ca.gov/programs/Pages/RadiologicHealthBranch.aspx

PER CALIFORNIA CODE OF REGULATIONS, TITLE 17, SECTION 30255: CALIFORNIA RADIATION CONTROL REGULATION, RADIOACTIVE MATERIAL LICENSE, SPECIFIC RADIATION SAFETY INSTRUCTIONS AND OPERATING PROCEDURES ARE AVAILABLE FOR REFERENCE AT CHS A6-060C, ext. 5-5396

Radioactive Material Users

Radioactive material users directly handle radioactive material. EH&S offers an initial training course called the New Radiation Worker Qualification that must be completed by each user prior to beginning work. The course material covers such topics as:

- Responsibilities of employees and of the organization
- EH&S policies and procedures
- Radioactivity and radioactive decay
- Nuclear characteristics of ionizing radiation
- Mode of exposure
- Fundamental protective measures
- Biological effects of exposure
- Regulatory dose limits
- Basic radiation survey instrumentation
- Contamination control
- Emergency response

Radiation-Producing Machine Operators

Radiation-producing machine operators perform work with radiation-producing machines. EH&S offers initial training courses for new radiation-producing machine operators, based on the type of machine that will be used. An in-person training course is offered for diffraction and fluorescence users known as X-Ray Diffraction Safety Training. The course material covers such topics as:

- Responsibilities of employees and of the organization
- EH&S policies and procedures
- Analytical uses of x-rays

- Fundamental protective measures
- Biological effects of exposure
- Regulatory dose limits
- Emergency response

Cabinet x-ray and linear accelerator users should contact EH&S to arrange for training and administration of examinations.

PERIPHERAL WORKERS

Ancillary laboratory personnel, also called peripheral workers, who do not work directly with ionizing radiation but work regularly in areas where it is used are not required to complete a formal EH&S initial radiation safety training course, but must receive hazard awareness training under the guidance of the PI. PIs and laboratory staff should refer to the Lab Safety Training Matrix to ensure that each individual receives appropriate training based on their work functions. While basic radiation safety hazard information is presented in the EH&S Laboratory Safety Fundamentals course, all laboratory staff must also be trained on the specific hazards present in their laboratory environment, under the guidance of the PI. This training should be documented.

SERVICE PERSONNEL

Service personnel may perform occasional or short-term tasks in areas where radioactive materials or radiation-producing machines are authorized for use. These types of tasks include custodial services, equipment maintenance or repair, or laboratory renovations and remodels. Generally, these workers are not expected to receive additional radiation exposure beyond that received by the general public. These individuals will be trained by EH&S, as appropriate. It is important to notify EH&S of any expected repairs, remodeling, or renovations so appropriate training is given to the personnel involved.

LABORATORY VISITORS

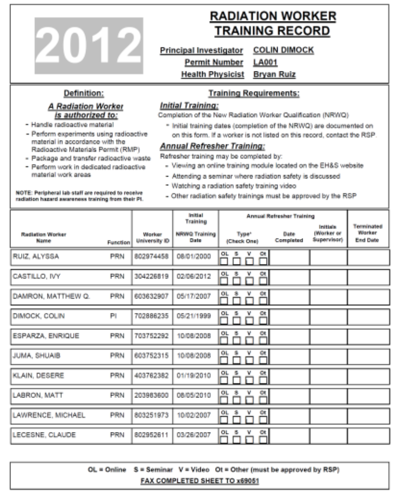
Visitors are individuals who do not work in radioactive material use laboratories but may enter these rooms for short periods of time. Visitors do not require documented formal training as long as they are under the supervision of a trained individual. The visitor must be apprised of any relevant campus policies that they must comply with and should also receive brief hazard awareness training, as needed. *A visitor's radiation exposure may not exceed the limits allowed to a member of the general public (**2 mrem in any one hour**).*

Annual Radiation Safety Refresher Training

Annual radiation safety refresher training, also referred to as continuing training, is required for all radioactive material users and radiation-producing machine operators, including PIs.

Radiation-producing machine operators should contact the EH&S Radiation Safety Program for current annual refresher training requirements. Annual refresher training for **radioactive material users** may be obtained in several ways, as indicated below:

Figure 4.3 – Radiation Worker Training Record



2012

RADIATION WORKER TRAINING RECORD

Principal Investigator COLIN DIMOCK
Permit Number LA001
Health Physicist Bryan Ruiz

Definition:

A Radiation Worker is authorized to:

- Handle radioactive material
- Perform experiments using radioactive material in accordance with the Radioactive Materials Permit (RMP)
- Package and transfer radioactive waste
- Perform work in dedicated radioactive material work areas

NOTE: Peripheral lab staff are required to receive radiation hazard awareness training from their PI.

Training Requirements:

Initial Training:
Completion of the New Radiation Worker Qualification (NRWQ)

- Initial training dates (completion of the NRWQ) are documented on on this form. If a worker is not listed on this record, contact the RSP.

Annual Refresher Training:
Refresher training may be completed by:

- Viewing an online training module located on the EH&S website
- Attending a seminar where radiation safety is discussed
- Watching a radiation safety training video
- Other radiation safety trainings must be approved by the RSP

Radiation Worker Name	Function	Worker University ID	Initial Training NRWQ Training Date	Annual Refresher Training Type* (Check One)	Annual Refresher Training Date Completed	Annual Refresher Training Initials (Worker or Supervisor)	Terminated Worker End Date
RUIZ, ALYSSA	PRN	802974458	08/01/2000	☐ OL ☐ S ☐ V ☐ Ot			
CASTILLO, IVY	PRN	304226819	02/06/2012	☐ OL ☐ S ☐ V ☐ Ot			
DAMRON, MATTHEW Q.	PRN	603632907	05/17/2007	☐ OL ☐ S ☐ V ☐ Ot			
DIMOCK, COLIN	PI	702886235	05/21/1999	☐ OL ☐ S ☐ V ☐ Ot			
ESPARZA, ENRIQUE	PRN	703752292	10/08/2008	☐ OL ☐ S ☐ V ☐ Ot			
JUMA, SHUAIB	PRN	603752315	10/08/2008	☐ OL ☐ S ☐ V ☐ Ot			
KLAIN, DESERE	PRN	403762382	01/19/2010	☐ OL ☐ S ☐ V ☐ Ot			
LABRON, MATT	PRN	203983600	08/05/2010	☐ OL ☐ S ☐ V ☐ Ot			
LAWRENCE, MICHAEL	PRN	803251973	10/02/2007	☐ OL ☐ S ☐ V ☐ Ot			
LECESNE, CLAUDE	PRN	802952611	03/26/2007	☐ OL ☐ S ☐ V ☐ Ot			

OL = Online S = Seminar V = Video Ot = Other (must be approved by RSP)
FAX COMPLETED SHEET TO x69051

- Attend a radiation safety training session. Persons wishing to complete their refresher training by attending a radiation safety training session will not be required to complete the examination.
- View an online radiation safety training module. Online training modules are available through the EH&S website at *www.ehs.ucla.edu*. Only one training module must be viewed to satisfy the refresher training requirement.
- View a radiation safety video. Visit the EH&S website at *www.ehs.ucla.edu* to view our video selection. You may also supply your own video and provide the video name and manufacturer to EH&S
- Read the EH&S radiation safety annual refresher training handout. The handout is a printable version of the current online training module.
- Attend a seminar on the topic of radiation safety. These seminars may be conducted at UCLA, during a lab meeting, or at another institution. To receive credit for attending a seminar, provide the course topic material to EH&S, along with the name of the institution and instructor.
- Attend a radiation safety seminar presented by EH&S. Special seminars offered by EH&S personnel are available upon request, and are subject to staff availability.
- Course work and/or professional education. Individuals who teach radiation courses or who are attending a course that includes radiation safety topics can satisfy the annual refresher training requirement by providing the course topic material along with the name of the institution and instructor.

Chapter 5: Protection Against Radiation Exposure

Introduction

Radiation is defined as the emission and propagation of energy through space or matter by high-speed particles or electromagnetic radiation. At high enough energies, radiation has the ability to ionize matter and can cause adverse health effects. Therefore, it is important to understand the nature of ionizing radiation so that one may harness the benefits of working with radioactive material or radiation-producing machines while minimizing its risk. An effective radiation safety program implements control methods to ensure that when individual users conduct their work, they do so in a safe and efficient manner such that radiation dose is kept as low as reasonably achievable (ALARA).

Radiation exposure can be minimized by using both administrative and engineering controls.

Administrative Controls	Engineering Controls
• Safe handling procedures • Personnel training • Proper labeling, signage and postings • Frequent safety audits	• Fume hoods • Mechanical interlocks • Shielding • Alarming area monitors

These controls vary in their usefulness and are dependent on the quantity of radioactive material, its chemical form, and the characteristics of the radioactive emission.

Protection Against External Radiation Exposure

External radiation exposure is significantly reduced by applying the concept of time, distance, and shielding (TDS):

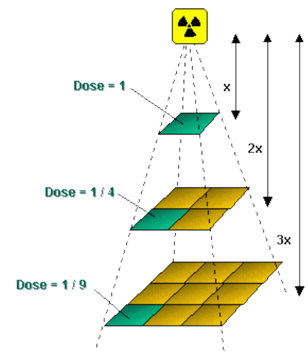
TIME

Time directly influences the dose received; minimizing time spent near radiation sources will minimize the dose received. Planning a work procedure, following the procedure, and often performing a "dry" run will create a sound foundation for successful procedures. For example, before adding a radioactive tracer to a compound, practicing the procedure using water instead of the active tracer will allow the lab worker to become familiar with the steps involved. Additionally, having all materials and equipment ready for use prior to removing the stock vial of radioactive material from storage also reduces exposure time. Similarly, one should not spend time unnecessarily in an area where radioactive materials are stored. If a problem arises during a procedure, move away from the source and discuss options with fellow lab workers. Return the radioactive material to storage, if possible.

DISTANCE

Procedures using radioactive material or radiation-producing machines should be planned so as much distance as possible is maintained between the source and the worker. The radiation intensity diminishes rapidly as the distance from the source is increased. This relationship follows the inverse square law in which the exposure from a radiation source decreases by the inverse of the distance squared, as indicated in the equation below:

Figure 5.1 – Inverse Square Law for Point Sources



Inverse Square Law for Point Sources:

$$X_a d_a^2 = X_b d_b^2$$

Where:

X_a = Exposure rate at distance, **a**
X_b = Exposure rate at distance, **b**
d_a = Distance, **a**, from point source
d_b = Distance, **b**, from point source

Utilizing tweezers or tongs during radioactive material handling significantly reduces the external exposure to the hands, as compared to holding a radioactive stock vial or source directly. Distance also provides some protective effect through the shielding provided by air between the source and the user, in the case of low-energy beta emitting radioisotopes.

SHIELDING

Shielding a source of radiation will reduce the radiation intensity around the radioactive source. Shields can take many forms, such as: lead "pigs" or stock vial shielding, lead aprons, syringe shields, vial shields, and countertop shields. Shielding should be utilized whenever appropriate, such as when the source is in storage, being actively used, and around radioactive waste receptacles.

Alpha Shielding

Alpha particles do not pose an external exposure hazard and shielding is not necessary. However, alpha particles are of great concern because of their potential attribution to internal exposure.

Beta Shielding

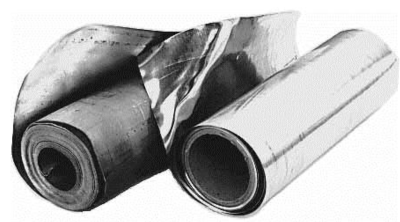
Beta (electron) particles are able to traverse up to several meters in air, depending on their energy. If an absorber of increasing thickness is placed between the beta source and a detector, the counting rate will fall off until no net counts can be detected. The maximum thickness the beta particles will penetrate is called the **range**. Typically, Plexiglas™ at a thickness of approximately (1) cm is used for beta shielding at UCLA. This is a sufficient thickness to absorb the maximum beta energies emitted from P-32, as well as lower energy beta emitters.

Beta-emitting radioisotopes require considerations for handling and shielding that differ from that of gamma rays or x-rays. Middle to high energy range beta-emitting radioisotopes interact with shielding material and are able to produce photons, or x-rays, due to the deceleration of the beta particle as it interacts with the atoms contained in the shield. The production of x-rays during this process, known as Bremsstrahlung or "braking radiation", increases with the increasing atomic number, or Z-number, of the shielding material. For this reason, plastic should always be used in lieu of denser materials, such as lead, to minimize x-ray production when shielding beta-emitting radioisotopes. However, with high energy beta-emitting radioisotopes such as P-32, lead shielding may need to be added to the outside of the plastic shielding to decrease the exposure from the Bremsstrahlung x-rays.

When considering the shielding requirements for positively charged beta particles, or positrons, it is important to note that characteristic 511 keV photons will be produced during a process termed "annihilation", in which a positron combines with a negatively charged electron. The photons produced during this process may require the addition of lead shielding to reduce exposure to acceptable levels.

Gamma or X-Ray Shielding

As gamma and x-rays are considerably more penetrating than beta particles, they require more shielding. The amount of shielding needed will depend on source strength. A shield built to absorb beta particles from a particular radioisotope will absorb the particles regardless of the strength of the source. In contrast, a shield designed to absorb gamma emissions, or photons, will always allow a fraction of the photons to pass through the shielding material. This fraction will, however, decrease as the thickness of the shield increases and as the atomic number, or Z-number, increases.



When shielding gamma or x-rays, materials with high atomic numbers such as lead are preferred. While the required thickness of lead is independent of the source-to-shield distance, one can save significantly on the cost of material if the shield is close to the source.

Calculations for shielding of gamma or x-rays can be made readily with the use of half-value layer (HVL) or tenth-value layer data of the attenuating medium. The HVL describes the thickness in which 50 percent of incident photons will be attenuated by a specified medium. HVL information for several commonly used gamma-emitting radioisotopes may be found in Appendix A – *Theory of Ionizing Radiation*.

Neutron Shielding

Considerations regarding neutron shielding constitute a complex issue encompassing attenuation of both neutron and gamma photons, and is beyond the scope of this manual. With that said, the concepts of time, distance, and shielding in connection with protection from external exposure due to gamma photon production apply equally well to exposure to neutrons

Protection Against Internal Radiation Exposure

Radioactive material may enter the body through one of four pathways: inhalation, ingestion, absorption, and injection. While engineering controls are useful in protecting individuals from potential internal exposure due to inhalation of volatile radioisotopes, it is up to the individual to assume personal responsibility for a safe work environment. Each laboratory member must be suitably trained on all pertinent standard operating procedures for the scope of work performed. These procedures must include radiation safety related information, in addition to outlining the physical steps performed during the experiment. Each procedure should indicate what personal protective equipment (PPE) is required, how to dispose of contaminated waste and sharps, engineering controls that must be used while handling radioisotopes (e.g., fume hoods, biosafety cabinets), and the frequency of personal and work area contamination surveys (**before** and **after** each experiment).

UCLA Policy 905 (*http://www.adminpolicies.ucla.edu/app/Default.aspx?&id=905*) must be followed regarding the personal protective equipment requirements when entering or working in hazardous material use environments. Additionally, EH&S has established a Radioactive Material Use Laboratory Food and Drink policy that must be adhered to by all laboratories using unsealed radioactive material. These policies may be found on the EH&S website (*www.ehs.ucla.edu*) and in Appendix D of this manual.

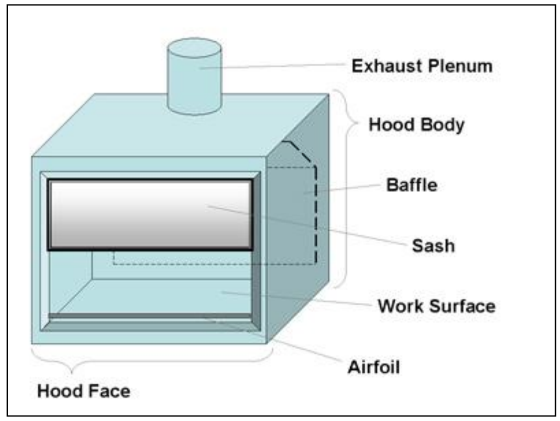
Administrative Laboratory Guidelines

- ✓ Individuals working in, or visiting, a laboratory using unsealed radioactive material must always be in compliance with the UCLA Personal Protective Equipment Policy 905 (*http://www.adminpolicies.ucla.edu/app/Default.aspx?&id=905*).
    - Closed-toe shoes and long pants (or equivalent) are required when entering or working in radioactive material use laboratories that use unsealed material.
    - Gloves, lab coats, and eye protection must be worn during any and all operations in which unsealed radioactive material is used and there exists a potential for contamination.
- ✓ Personnel should frequently monitor their hands, clothing, and shoes for contamination during and after each experiment with radioactive material.
- ✓ There will be no food or drink consumption or storage in any unsealed radioactive material use labs at any time. This also applies to personal items such as make-up, lip balm, etc. Do not dispose of food, empty food wrappers, or beverage containers anywhere in the lab.
- ✓ Hands should be washed thoroughly with soap and water prior to leaving the laboratory.
- ✓ All work with volatile materials will be performed in a certified radioactive material use fume hood.
- ✓ Appropriate shielding will be used to keep external radiation exposure ALARA, as appropriate.
- ✓ Radioactive material use areas and equipment will be monitored with an appropriate calibrated survey meter to ensure that contamination is not present and that radiation fields are kept ALARA.
- ✓ All contaminated waste must be disposed of in appropriate waste receptacles that indicate the radioisotope and are labeled with standard radiation warnings.
- ✓ All sharps must be disposed of in proper sharps containers and must not be overfilled. All syringes must be capped while not in use.

Fume Hoods

The purpose of a laboratory fume hood is to minimize or eliminate worker exposure to hazardous volatile contaminants, including radioactive material, and to provide dilution and dispersal of the contaminants. The principal contaminant control factor in the use of hoods is the flow of air across the hood face and into the exhaust system. Fume hood face velocities must be maintained at 100 feet per minute (ft/min), and the hood must be kept clear and operated with the sash in the designated position (as marked by labels affixed to the edge of the hood opening). Chemical fume hoods are tested at least once annually to ensure that the air velocity is at least 100 ft/min. Such tests are done regularly by EH&S. EH&S should be contacted immediately if it is suspected that a fume hood is not functioning as it is designed. The hood will be checked promptly and arrangements made for repair, if necessary.

Figure 5.2 – Fume Hood



Laminar flow hoods using recirculating air are unsuitable for work with radioactive isotopes, with the exception of procedures in which only a few microcuries are used. Determination of the need for a hood is based on the quantity of the volatile isotope used per procedure.

Mini-hoods & Radioiodine Use

The use of carrier-free radioiodine isotopes may require special precautions because of their volatility and affinity for the thyroid. Mini-hoods, which are sometimes used with radioiodine isotopes under specific circumstances, must be carefully maintained and surveyed to ensure proper performance. A small fan pulling air through access ports and exhausts through an activated charcoal filter into the regular fume hood exhaust provides airflow.

The mini-hoods must be used inside a functioning fume hood that is certified with the mini-hood installed and functioning. The mini-hoods must not be moved from one hood to another without the approval of EH&S.

- If a mini-hood is taken out of service, whether temporarily to free the main hood for another experiment or permanently, it must be monitored and decontaminated (if necessary). If removal is permanent, the charcoal filter must be removed and disposed as radioactive waste.
- If removal is temporary, the entire hood may be sealed in a large heavy plastic bag that should not be reopened unless in a fume hood due to possible re-suspension of radioiodine from the filters.

Standard operating procedures for experiments involving the use of the mini-hood should include information on the following:

- How to use the mini-hood properly to maximize efficiency.
- Leaving the blower motor on the mini-hood in continuous operation following an experiment to ensure that the amount and direction of airflow through the contaminated filters is maintained.
- Contamination survey frequency – the mini-hood armholes should be surveyed for contamination after each experiment to prevent the spread of contamination.

The charcoal filters used in mini-hoods should be changed periodically. Change is recommended under any of the following conditions:

- If the exposure rate from the filter is 0.6 milliroentgen(R)/hr or above at the nearest accessible external point.

- If either the pre-filter or the charcoal-filter show a loading from dust or debris that could reduce airflow.
- At least once annually. It is difficult to assess the continued efficiency of the charcoal over various uses and atmospheric conditions. The filter should be changed before it is no longer functioning properly.

Chapter 6: Radiation Detection

Introduction

Since ionizing radiation cannot normally be detected through the senses, instruments must be relied on and utilized for the detection and measurement of radioactive contamination and radiation fields. As a wide range of radiation-monitoring instruments are available, care must be taken to select an instrument both appropriate and efficient for the application. In this chapter, the measurement principles of radiation detectors, the requirements of possessing a detector, and the general guidelines for using a detector will be presented.

Detector Type	Radioisotopes	Comments
GM (Geiger-Mueller) Survey Meter	C-14, S-35, P-33, P-32	• Can be used to find gross surface contamination • Does not detect H-3 or any very low energy beta • Inefficient for detection of photons (x-rays, gamma rays) • Typically measures in counts per minute (cpm)
Ionization Chamber	Gamma or x-ray fields	• Measures exposure rate due to gamma or x-rays • Measures exposure rate due to Bremsstrahlung radiation from beta particles • Typically measured in µroentgen(R)/hr or mR/hr
NaI (Sodium Iodide) Survey Meter	I-125, Cr-51	• Much more efficient at detecting gamma radiation than GM meter • Fragile and very hygroscopic • Measured in cpm
Liquid Scintillation Counter	H-3, C-14, S-35, P-33, P-32, I-125, Cr-51	• Able to quantify H-3 • Most sensitive detection method for beta particles, although measurement is applicable to all types of emissions • Measured in cpm or disintegrations per minute (dpm)
Gamma Counter	I-125, Cr-51 and other gamma-emitting isotopes	• Efficient detection method for gamma-emitting isotopes • Measured in cpm or dpm

Principal investigators (PI) working with beta- (e.g., C-14, S-35, P-33, P-32) or gamma-emitting radioisotopes (e.g., I-125, Cr-51) should possess or have access to a portable radiation detector with the appropriate probe. Certain labs with only sealed sources presenting a minimal radiation exposure hazard are not required to possess a radiation detector. Labs working **only** with H-3 are not required to possess a portable radiation detector. However, they must have access to a liquid scintillation counter for all post-experiment and monthly surveys.

Portable Survey Instruments

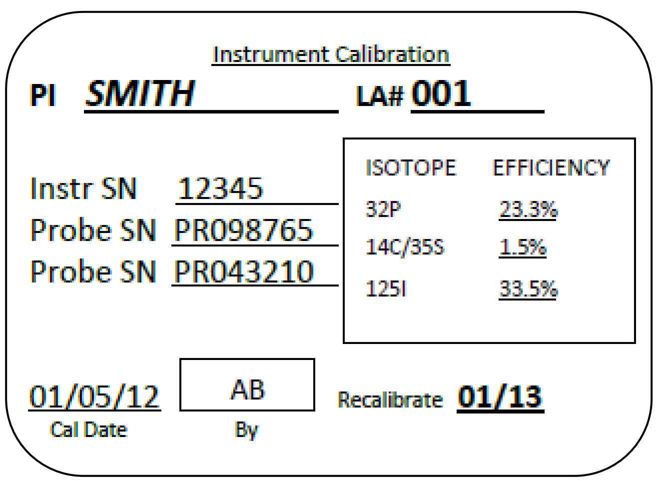
The basic operating principles for detecting and measuring radiation are usually based on radiation interactions within either a gas-filled detector or solid scintillation crystal. In a gas-filled detector, ion pairs (a positive ion and an electron) are produced when a radiation emission ionizes the detector gas or chamber wall. The detector, which is composed of charged electrodes placed in the medium, collects the ion pairs and amplifies this signal to produce another signal. There are a number of different types of portable radiation detectors that operate on this basic principle including the Geiger-Mueller (GM) detector, ionization chamber, and proportional counter.

Another type of portable survey meter operates under the principle of scintillation detection. Essentially, a scintillation detector is a transducer that changes the kinetic energy of the incoming radiation into a pulse of light. This signal is sent through a photomultiplier tube where released electrons are transformed into an electrical pulse that can be sorted and counted. Scintillation detectors, used with a portable survey meter, are primarily used to detect gamma rays emitted from various radioisotopes.

Calibrations and Efficiency

All radiation detection instruments used for quantitative and qualitative measurements must be calibrated or response-checked every 12 months. Calibrations shall be performed either by EH&S, the instrument manufacturer, or a licensed calibration service provider. If the calibration label affixed on the side of instruments indicate that the last calibration date has been exceeded by one year, do not use the detector and notify EH&S immediately.

A portion of the calibration procedure is conducted using a set of sealed check sources containing known amounts of activity. The percentage of known activity that the instrument detects is known as the efficiency of the instrument. The detection efficiencies for common radioisotopes are provided on the calibration label (see diagram).



GEIGER-MUELLER (GM) DETECTORS

One of the most widely used instruments is the Geiger-Mueller detector. They are simple to use and can detect radiation at very low activity levels due to their large charge amplification. A primary purpose of these detectors is the detection of surface contamination from beta-emitting isotopes like C-14, P-32, and S-35.

In a Geiger-Mueller detector, a single ionizing event will induce a massive amount of gas multiplication and create a very large output pulse. The size of the large output pulse is independent of the amount of ionization produced by the incoming radiation. In other words, the pulse is the same regardless of the type of radiation (e.g., alpha, beta, or gamma). For this reason, most Geiger-Mueller detectors are calibrated in counts per minute (cpm); the response does not account for the energy of the emission. If calibrated to a fixed x-ray or gamma ray energy, however, the Geiger-Mueller detector is capable of measuring exposure rates for that particular fixed energy. As the energy of x-rays or gamma rays will vary in different labs, EH&S calibrates Geiger-Mueller detectors in counts per minute, rather than disintegrations per minute (dpm).

Due to the rapid response of Geiger-Mueller detectors, they can become “saturated” by exceptionally high radiation fields. At this point, the meter will become paralyzed and cease to function. An ionization chamber would be better suited for these scenarios, where high level radiation fields are present.

The efficiency of the Geiger-Mueller detector is affected by the energy of the radiation being detected. Incoming radiation, once emitted, must pass through various barriers (i.e., air, protective screen, and mica window) before it can enter the active chamber and interact with counting gas to be detected. For this reason, low energy beta emitters, like H-3 (maximum energy (E_{max}) = 18.6 keV), possess insufficient energy to penetrate the mica window and, thus, cannot be detected by a Geiger-Mueller detector. For practical purposes, C-14 (E_{max} = 156 keV) is the lowest energy beta emitter that can be quantified with this type of detector. Due to the uncharged nature of photons, the efficiency of Geiger-Mueller detectors to detect photons is quite low. As a result, these detectors should not be used for I-125 as the measured efficiency for this isotope is less than 1%.

Guidelines for the Use of Radiation Detectors

Things to Remember:

- **Geiger-Mueller detectors will not detect tritium (H-3) or other very low-energy beta-emitting radioisotopes. This class of radioisotopes must be evaluated using a liquid scintillation counter or other windowless detector.**
- **Geiger-Mueller detectors are highly inefficient at detecting low-energy gamma ray sources (I-125). A thin-window sodium iodide (NaI(Tl)) scintillation probe should be used instead.**

Operating Procedure:

- **Before use, look over the instrument carefully and check for any signs of damage to the detector, probe, or cable.**
- **Check the calibration certificate label affixed to the detector. Confirm the calibration date has not been exceeded by one year.**
- **Check the batteries. Before each use, use the battery check switch to ensure there is enough battery to operate the detector. Replace weak batteries if needed. Turn off the instrument when not in use. (Note: When storing the instrument for extended periods, remove the batteries to prevent damage from battery acid leakage.)**
- **If a check source is present on the detector, check for a response and compare the results to those indicated on the calibration sticker.**
- **The audible indicator will help the operator notice an increase in the count rate without looking at the meter.**
- **The instrument response time should be set to:**
- **"Fast" - when surveying in order to get the quickest needle response to contamination.**
- **"Slow" - When an accurate count rate is needed; generally whenever the lowest count rate setting is in use.**
- **Begin all measurements on the lowest scale first (usually x0.1 or x1), then increase the scale as appropriate.**
- **Survey slowly. The detection sensitivity of the instrument decreases with increased survey speed. Use a slow sweeping motion that is no more than two inches per second.**
- Survey **at the proper geometry. The detector should be held as close to the surface as possible without touching it. Typically, a detector-to-surface height of 1 cm or ½ inch is used. This will ensure maximum sensitivity while not contaminating the detector.**
- Do **not use a Geiger-Mueller detector probe for contamination surveying while it is covered with a plastic cap. Additionally, do not cover the probes with plastic film, as the plastic.**

IONIZATION CHAMBERS

Ionization chambers are most frequently used in locations where external radiation field hazards are present. These instruments measure the ionization produced in air and are a good indicator of radiation exposure.

In an ionization chamber, the number of ions collected by the electrode will be equal to the number produced by the primary ionizing particle. This type of detector accounts for the type and energy of radiation and, subsequently, can give a good estimate of dose.
When used as a survey meter, an ionization chamber's current reading is used to measure the rate of gamma or x-radiation exposure and is expressed in units of roentgens (R) or mR per hour. The roentgen is defined as the number of ionizations produced per kilogram of dry air under standard temperature and pressure where:

$$1 \text{ R} = 2.58 \times 10^{-4} \text{ coulombs (C) [or } 2 \times 10^{8} \text{ ion pairs]}$$

It is important to remember that the roentgen is a measure of the ionizing potential of x-ray and gamma radiation in air. For the purposes of practical radiation protection in humans, however, roentgen and units of radiation dose – such as the rad – can all be considered equivalent for x- and gamma radiation.

PROPORTIONAL COUNTERS

Proportional counters are more sensitive than ionization chambers. When compared with Geiger-Mueller detectors, proportional counters also have a better response to low energy photons and sensitivity to beta radiation. They are, however, costly and have some technical requirements which can be a disadvantage for certain applications.

The proportional counter is particularly suitable for counting particle emissions, as well as distinguishing among various types of radiation based on the pulse size. This is due to the fact that the pulse produced in a proportional counter is proportional to the initial ionization.

A neutron detector is another example of a proportional counter. A neutron detector will either utilize boron-10 as a counter filling gas consisting of BF_3, or as a solid layer of boron coated within a detector. When a boron-10 nucleus captures a thermal neutron, an alpha particle is produced. The alpha particle that is created within the proportional counter can then be easily counted.

SODIUM IODIDE SCINTILLATION DETECTORS

A portable scintillation detector is ideal for the detection of gamma-emitting radioisotopes. The active portion for detecting radioactivity is a solid scintillator crystal with which the incoming radiation will interact. One of the most commonly used scintillating crystals is sodium iodide in which a small amount of thallium has been added (NaI(Tl)). A sodium iodide crystal's high density, high atomic number, and good light yield results in high detection efficiency for gamma photons. However, they are fragile, very hygroscopic and must be protected from moisture.

When gamma rays interact with a scintillation crystal, electrons are raised from one energy state to a higher energy state. As the electrons return to their original ground state, light is released.

The photons of light are then directed upon a photomultiplier tube, which effectively converts the photons back into an amplified electronic signal. Accordingly, the size of the resulting signal is proportional to the energy dissipated in the detector by the incident radiation.

The detection efficiency of NaI(Tl) scintillation detectors decrease with increasing energy of the incident gamma rays. Therefore, it is important to choose the correct thickness of the scintillation crystal to maximize the detection efficiency for whichever radioisotope one is working with. For example, a low energy gamma scintillator with a 1mm thick NaI(Tl) crystal is sufficiently thick to detect the 35.5 keV gamma photons from I-125, but Cr-51 photons of 320 keV will largely penetrate the crystal without interaction. For better detection efficiency for high energy gamma radiation, a thicker 1” crystal should be used.

Low energy gamma: I-125	NaI(Tl): 1 inch x **1 mm**
High energy gamma: Cr-51	NaI(Tl): 1 inch x **1 inch**

Liquid Scintillation Counters

Liquid scintillation counters (LSC) are large, non-portable machines used to measure removable radioactive contamination on swipes and are effective for quantifying alpha-, beta- and gamma-emitting nuclides. In order to detect low energy beta particles (H-3) a liquid scintillation counter is used as few other instruments can provide the necessary sensitivity. This enhanced sensitivity is due to the radioactive sample being mixed thoroughly with a scintillating material, thereby minimizing the amount of attenuation between the sample and the scintillating material.

The scintillation solution or “cocktail” in which the radioactive sample is mixed is composed of two main components: the solvent and the primary fluor (solute). Solvents will dissolve the sample and transfer energy from the radiation to the fluor in the scintillation mixture. Upon receipt of the energy, the primary fluor will release light, which is then read by photomultiplier tubes in the detector. The resulting light pulses emitted are proportional to the energy imparted to the scintillator by the radioisotope particle.

Perhaps one of the biggest advantages of a liquid scintillation counter is its increased counting efficiency. Under ideal conditions, the efficiency can range from 50% for tritium, to nearly 100% for P-32, a high-energy beta emitter, and for most alpha emitters. Liquid scintillation counters also offer the advantage of additional discrimination by means of selecting a specified energy range through the use of upper- and lower-level discriminators called a window. Two or three windows are typically employed in liquid scintillation counters to separate contributions from several radioisotopes counted simultaneously.

Guidelines for the Use of Liquid Scintillation Counters

Operating procedure:

- **Swipe samples are obtained by swiping a 100cm^2 surface with absorbent materials (such as filter paper) using moderate pressure.**
- **Place samples into liquid scintillation counting vials and the correct amount of liquid scintillation cocktail. Include a background vial, which contains scintillation cocktail and a non-radioactive sample.**

Place sample vials with background vial into the liquid scintillation counter tray (or belt) and place into the counter.

- **Set an appropriate count time. Shorter count times result in poor counting statistics. (Note: a 3-minute count time is generally sufficient for quantifying contamination.)**
- **Determine your sample activity in disintegrations per minute (dpm) from the reported counts per minute (cpm) by dividing the number of counts by the efficiency (dpm = cpm/efficiency).**

Typical LSC Efficiencies	
H-3	50%
All Other Beta	95%
I-125	75%
Cr-51	37%

Gamma Counters

A gamma counter is a non-portable machine utilizing a large sodium iodide crystal for quantifying the activity of gamma-emitting samples. As described earlier, an efficient method to detect and measure gamma radiation is through the use of a sodium iodide crystal coupled to a photomultiplier tube. A large sodium iodide crystal with a central hole or "well", will allow a sample to be surrounded by the crystal, resulting in very high detection efficiency.

As with the sodium iodide survey meter, the efficiency of detection is dependent on the thickness of the crystal. For any crystal size, if the energy of the photon is too low, the photons of light created can be reabsorbed by the crystal and never detected. On the other hand, if the energy is too high, the photon may pass straight through the crystal without interaction. Commercially available gamma counters are generally well optimized for laboratory use.

Unlike liquid scintillation counting, the sample can be counted in any form and does not require any special preparation. However, proper containment techniques should be utilized so as to not contaminate the detector.

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Chapter 7: Radiation Safety Surveys

Introduction

Once a room has been approved for radioactive material or radiation-producing machine use, and is listed on a PI's Radioactive Materials or Radiation-Producing Machine Permit, radiation safety surveys need to be performed in that room at a specific set frequency. Radiation safety surveys are not only a requirement of UCLA's broad scope radioactive material license, but also serve as a means of evaluating the effectiveness of a radiation protection program in the laboratory setting.

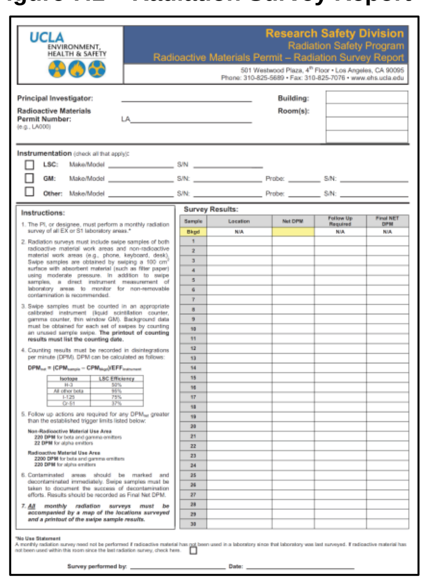
The PI who is authorized to use radioactive material or radiation-producing machines is responsible for maintaining a safe working environment in the lab by providing and ensuring the use of appropriate survey instrumentation, equipment, facilities, and procedures.

This chapter will address the requirements and responsibilities for proper surveying of radioactive material use laboratory rooms by the PI or appropriate designate. This chapter does not pertain to radiation safety survey requirements for radiation-producing machines. For more information, refer to Chapter 3: *Radiation-Producing Machine Permits*.

Commissioning of Radioactive Material Use Laboratories and Equipment

In the event that a PI wishes to add radioactive material use laboratory space to their permit, the room must first be commissioned by EH&S before any radioactive material may be used. All necessary equipment including shielding, instrumentation, waste containment, personal protective equipment (PPE), and caution labeling must be in place before a laboratory is commissioned. Once these materials are obtained, the PI or Radiation Safety Supervisor should contact their group's designated health physicist to schedule a commissioning survey. Scheduling commissioning surveys is a timely process and should be planned well in advance.

Figure 7.1 – Radiation Survey Report



Laboratory Surveys

The PI (or qualified designee) is required to perform surveys of their approved radioactive material use laboratory rooms. The surveys must be documented on the Radiation Survey Report provided by EH&S (Figure 7.1). The intent of these surveys is to ensure the timely detection of radioactive contamination and to prompt necessary decontamination efforts before contamination is spread throughout the laboratory and beyond.

1. **Room Types:** When a PI is approved by EH&S to work with radioactive material in a laboratory room, one of three types of room designations may be assigned and will determine the PI's responsibility for

that space:

- Exclusive User (EX): This signifies that the PI's laboratory group is the only lab group allowed to work with radioactive material in the room.
- Primary User (S1): This signifies that there are multiple laboratory groups working with radioactive material in the room. As the S1 user, this PI is responsible for all radiation safety aspects of the room, including the monthly survey and radioactive waste disposal.
- Secondary User (S2): This signifies that there are multiple laboratory groups working with radioactive material in the room. As an S2 user, this PI is not directly responsible for certain radiation safety aspects of the room, such as documented monthly contamination surveys. However, the S2 user must continue to follow all applicable EH&S policies and abide by the limitations of their Radioactive Materials Permit.

2. **Frequency:** EH&S strongly recommends that surveys be performed **during and after** experiments involving unsealed radioactive material. At a minimum, the PI (or qualified designee) must perform monthly radiation surveys of all laboratory rooms in which they are listed as the exclusive (EX) or primary (S1) user.

   If a lab is not actively using radioactive material, they may complete a "No Use Statement" survey by checking the box at the bottom of the monthly radiation survey report. However, if a laboratory is not actively using radioactive material but inventory is being stored in the laboratory, a radiation safety survey must be completed of the radioactive material storage areas and inventory containers once per quarter (every 3 months). A "No-Use Statement" may be completed at the bottom of the monthly Radiation Survey Report if:

   - The exclusive user of the laboratory room has not worked with radioactive material during the given month or since the last radiation survey.
   - Both shared primary and shared secondary users of the laboratory room(s) have not worked with radioactive material in the given month or since the last radiation survey.

3. **Survey Records:** Survey records must be maintained by the PI (or qualified designee). Each survey record must include:

   - The Laboratory Authorization (LA number) assigned to the permit, laboratory location by building, and room. All rooms on the permit that are designated as EX or S1 must be accounted for.
   - The signature of the surveyor and the date.
   - A map of the laboratory showing locations surveyed.
   - The make and model of all survey instrument(s) used and their respective serial numbers.
   - Results of survey swipe counting, including gross and background counts. If the survey instrument records the results in counts per minute (cpm), the results must be converted to disintegrations per minute (dpm). Please see the Radiation Survey Report for the conversion formula.
   - Actions taken to correct off-standard conditions and final results.

The counting of swipes and subsequent analysis must be performed within the given monthly period for a survey to be considered compliant. Radiation safety survey records are required to be available for audit EH&S personnel for a period of up to 3 years. Survey records older than 3 years may be archived until termination of the permit.

4. **Survey Guidelines:** Laboratory personnel should survey themselves and laboratory clothing before work breaks and at the end of the day. Work surfaces, equipment, floors, light switches, telephones, refrigerators, freezers, doors, and drawer handles should also be surveyed routinely. Effective monitoring includes measurements of radioactive contamination by both direct instrument measurement for fixed contamination, and counting of swipe samples for removable contamination. See Chapter 6: *Radiation Detection* for an explanation of direct versus indirect measuring techniques.

   The following guides concern survey techniques for commonly-used isotopes:

   - Direct radiation measurements may be inadequate for low-energy beta emitters (e.g., H-3) and swipe samples must be used for analysis. Swipe samples are obtained by swiping a 100 cm^2 surface with absorbent material using moderate pressure. Each swipe should cover approximately 100 cm^2 of an area such as a bench top, fume hood sash, or the floor in front of a work area.
   - Direct measurement of high-energy beta emitters (e.g., P-32, Sr-90) and photon emitters (e.g., Fe-59, Cr-51, I-125) should be performed with appropriately sensitive instruments.
   - If the observed contamination level exceeds the dpm values shown in Table 7.1, the area should be marked and decontaminated. Follow-up surveys should be performed after an area is cleaned to document the corrective action. If contamination persists, a change in laboratory procedure should be made.

Non-radioactive material use areas are those areas which can be readily accessed by non-radiation workers such as refrigerators, floors, and the outer layer of a radioactive waste container. Radioactive material work areas are those which are solely designated for radioactive material use and may include such items as the inside of a centrifuge or the inside of a radioactive waste container.

Table 7.1 – Limits for Removable Surface Radioactivity*

Type of Surface	Type of Emitter (in dpm/ minute per 100cm^2)	
	Alpha	**Beta/Gamma/X-ray**
Non-Radioactive Material Use Area	22	220
Radioactive Material Use Area	220	2,200
Personal Clothing (in public areas)	22	220
Personal Clothing (in restricted areas)	220	2,200
Skin	220	220

*Values referenced in Table 2 of NRC Regulatory Guide 8.23, Rev.1 – January, 1981

Clearance of Radioactive Material Use Laboratories, Equipment, or Furniture

PIs may not remodel a laboratory, relocate to a different laboratory, or abandon an existing radioactive material use area without the express written approval of EH&S. Abandoning a radiation use area without this approval is a violation of California law and may subject the PI and/or department to costly fines.

PIs wishing to remodel an existing radioactive material use area, relocate from one laboratory to another, or discontinue use of radioactive material in a laboratory must advise EH&S prior to any remodeling or relocation. EH&S will schedule a time with the PI to perform a clearance survey. Prior to the clearance survey, the PI (or qualified designee) may be required to do one or more of the following:

- Return all remaining radioisotopes to EH&S for disposal.
- If applicable, ensure that all personnel working on the project have completed their required bioassay measurements and returned their dosimetry to EH&S.
- Perform a final radiation survey of all laboratory areas to ensure that no contamination is present.
- Report findings to EH&S via mail or e-mail.

When EH&S has verified the adequacy of the close-out, a written release will be issued to the PI.

Equipment and laboratory furniture that has been used or stored in a laboratory or work area possessing uncontained sources of radioactive material may not be transferred to a general or non-radioactive material use area without the express approval of EH&S.

CLEARANCE OF EQUIPMENT CONTAINING INTERNAL RADIOACTIVE SOURCES (LIQUID SCINTILLATION COUNTERS, GAS CHROMATOGRAPHS, STATIC ELIMINATORS)

Special precautions must be taken for certain equipment such as liquid scintillation counters, gas chromatographs (electron capture detectors), and static eliminators. These instruments contain radioactive sources and must be removed by the vendor or by EH&S prior to disposal. EH&S must be contacted to ensure proper disposal or transfer of the installed radioactive material. If the manufacturer of the equipment will be removing the installed sources, EH&S should be informed prior to the source removal.

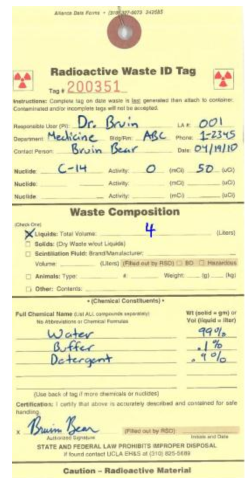
Chapter 8: Radioactive Waste

Introduction

Radioactive waste generated through research involving radioactive material is subject to strict Federal and State regulations, and must be handled and disposed of per EH&S guidelines. Prior to receiving approval to order and use radioactive material, Principal Investigators (PIs) must ensure that a method for the segregation, temporary storage, and transfer of radioactive waste is established. All experimental procedures involving the use of radioactive material must include written procedures regarding the handling of radioactive waste at the laboratory level.

Each laboratory must maintain accurate records of the types, quantities, and chemical forms of radioisotopes that comprise radioactive waste stored or transferred to EH&S. This information is also required when completing the radioactive material waste tag, which is provided by EH&S. Radioactive waste tags must be completed, in their entirety, prior to transferring the waste to EH&S. All activity amounts recorded must be as accurately as possible (Figure 8.1).

Figure 8.1 – Radioactive Waste Tag



Not all radioactive wastes generated at UCLA are described within this chapter. If you have questions regarding any procedure, or require additional information, please contact your assigned health physicist or EH&S via e-mail at *radiationsafety@ehs.ucla.edu*.

Types of Radioactive Waste

Five main types of radioactive waste are generated at UCLA; they include:

1. Dry solid
2. Aqueous liquid
3. Liquid Scintillation Vial (LSV)
4. Animal tissue
5. Mixed-hazard

Figure 8.2 – Beta Box Storage

DRY SOLID RADIOACTIVE WASTE

Dry solid waste includes the most common laboratory items such as gloves, paper products, and pipette tips. Free-standing liquid must **never** be placed in dry solid waste. When segregating dry waste, shielding should be considered. Many laboratories utilize beta box storage for beta-emitting radioisotope (Figure 8.2) or lead-lined containers for gamma-emitting radioactive waste. Dry solid waste must be double-bagged in thick (3 mil or greater), transparent bags and should be taped closed using a "J" seal (Figure 8.3) to secure contents.

Figure 8.3 – "J" Seal

Sharps should be placed in a sturdy plastic or cardboard container that is labeled with the word "SHARPS". The container should be taped closed and placed into a thick (3 mil or greater), transparent bag. Red sharps containers must not be used unless the sharps are biohazardous. Contact your assigned health physicist, or EH&S at *radiationsafety@ehs.ucla.edu*, if your research will generate waste that is both biohazardous and radioactive.

Figure 8.4 – Carboy

AQUEOUS LIQUID RADIOACTIVE WASTE

Aqueous liquid radioactive waste consists of free standing liquid stored in a plastic container such as a carboy (Figure 8.4). The aqueous liquid waste must not exceed 90% of the container capacity and containers must always be closed when not in active use. Liquid waste must always be stored and transported in secondary containment. When completing the radioactive waste tag, the chemical constituents and their volume percentages must be noted (e.g., 75% water, 20% saline buffer solution, and 5% ethanol) in addition to the other required information. It is best to use the generic term for the chemical constituent rather than the brand or specific chemical names. The total volume of the aqueous liquid waste is also required to be indicated on the radioactive waste tag.

LIQUID SCINTILLATION VIAL (LSV) RADIOACTIVE WASTE

Liquid scintillation vial waste is comprised of radioactive research samples, liquid scintillation counter standards, and laboratory survey swipes in vials that also contain liquid scintillation cocktail. It is recommended that the waste vials be stored in the original vial packing trays prior to transfer to EH&S for disposal. The vials must always be tightly capped when in storage or during transfer to prevent spillage of the contents. When transferring liquid scintillation vial waste to EH&S, the vials and trays should be double-bagged in thick (3 mil or greater), transparent bags and "J"-sealed using tape. When completing the radioactive waste tag, the brand and type of liquid scintillation cocktail must be noted, along with the total volume. The brand and type of scintillation cocktail determine whether the vial waste is biodegradable or hazardous.

Figure 8.5 – LSV Waste

RADIOACTIVE ANIMAL TISSUE WASTE

Radioactive animal carcasses, blood products, and tissues should be brought to the EH&S Radiation Safety Office located at the Center for Health Sciences (CHS), room A6-060C, for disposal. The animal tissue waste must be frozen and double-bagged in thick (3 mil or greater), opaque bags, and sealed using tape and a "J" seal. Absorbent material, such as chux, should be added in the event that the waste begins to thaw. In some instances, animal tissue waste may be stored in an approved, designated area of a laboratory until it has decayed to background radiation levels. This storage must be expressly approved by EH&S. If a laboratory is approved to store animal tissue waste for decay, specific procedures are required to ensure compliance with Federal and State regulations and UCLA policies. Contact your assigned health physicist directly or e-mail EH&S at *radiationsafety@ehs.ucla.edu* for more information.

MIXED-HAZARD RADIOACTIVE WASTE

Mixed-hazard radioactive waste consists of one or more hazards other than radioactivity (e.g., toxic, caustics, biohazardous) and is very costly to dispose of. In addition, these types of waste may pose a significant health hazard. If mixed-hazard radioactive wastes are expected to be generated during an experiment, first contact EH&S to receive guidance on the requirements for labeling, storage, waste tag completion, and transfer.

When possible, try to eliminate the other hazards, such as with neutralization (chemistry) or autoclaving/bleaching (biohazard) as part of the experimental procedure. This must be done prior to the material being classified as radioactive waste. The EH&S Radiation Safety Office should be contacted regarding neutralization of mixed-hazard material.

All mixed hazard radioactive waste must be tagged with a radioactive waste tag that includes chemical constituent information and volume percentages.

Radioactive Waste Minimization Guidelines

Whenever possible, the following guidelines should be used to minimize the production of radioactive waste.

GENERAL

- If radioactive contamination is present on a small area of bench-top liner or absorbent paper, the contaminated area may be cut away from the uncontaminated portion for disposal as radioactive waste. The remainder of the bench-top liner should be re-surveyed and, if no contamination is present, it may be disposed of as regular trash. Be sure to remove or deface any radioactive labels before disposing of the non-radioactive waste in the regular trash.
- Ensure proper segregation of radioactive and chemical waste. Do not mix chemicals and radioactive material unnecessarily, thereby creating mixed wastes.
- Substitute non-radioactive tracers for radioactive tracers.
- Do **NOT** treat any radioactive waste (e.g., neutralization, solidification) without permission from EH&S. Doing so may be a violation of Federal and State law.

DRY SOLID WASTE

- For dry waste, ensure that only contaminated material is disposed of as radioactive waste. Use appropriate radiation detection equipment (e.g., Geiger-Mueller or sodium iodide (NaI(Tl)) survey meter, swipe tests) to determine whether or not the material is contaminated before placing it in the radioactive waste container. If no detectable radioactivity is present above background levels, deface all radioactive symbols and place in the regular trash.

AQUEOUS LIQUID WASTE

- Segregate organic, toxic, or corrosive liquid wastes from aqueous, non-toxic, non-corrosive solutions.

- Aqueous solutions with a pH between 2 to 5 or 9 to 12.5 should be neutralized prior to placement in radioactive liquid waste containers. This process must be part of your written experimental protocol and you must receive approval from EH&S.

LIQUID SCINTILLATION VIAL WASTE

- Use biodegradable liquid scintillation fluids.
- Segregate liquid scintillation fluids with concentrations of H-3/C-14 less than 0.05 μCi/gram.
- Use smaller liquid scintillation vials instead of larger vials.

Radioactive Waste Storage in the Laboratory

It is the PI’s responsibility to secure proper storage for radioactive wastes. To minimize unnecessary radiation exposure, radioactive waste should not be stored in the laboratory for extended periods of time. This also helps prevent contamination due to waste container overfilling and reduces the possibility of the radioactive waste being disposed of improperly as regular trash.

Do’s and Don’ts of Radioactive Waste Storage	
Do	**Don’t**
• Store radioactive waste containers as close to the work area as feasible to minimize the possibility of spillage during the transfer of waste to the container. • Keep radioactive waste containers closed at all times when not in use. Aqueous liquid and LSV waste must be kept in secondary containment at all times, including during the transport to the radioactive waste pickup location. • Label each radioactive waste container with a radiation warning sticker (trefoil) on the top and side of the container, along with the isotope. • Store radioactive sharps in sturdy containers that are not **red** or labeled with other hazards.	• Do **NOT** place any radioactive waste in regular trash receptacles. Provide distinctly different containers for radioactive waste to avoid disposal in the regular trash. • Do **NOT** combine different radioisotopes in the same waste container unless you have prior authorization from EH&S to do so. Use a separate container for each isotope and waste stream. • Do **NOT** store radioactive waste containers outside of your authorized radioactive material use laboratories or leave them unattended in hallways, stairwells, or other uncontrolled areas. • Do **NOT** release radioactive waste into the sewage disposal system.

Radioactive Waste Packaging, Labeling, and Transfer For Disposal

PACKAGING

When packaging radioactive waste, take necessary precautions to prevent external contamination of the outer waste bag or liquid waste container. The waste containers must be monitored for contamination prior to transport. Properly packaged waste will contain the radioactive contents and will not have any contaminated outer surfaces.

LABELING

A properly completed radioactive waste tag must be affixed to each radioactive waste container or bag prior to transporting the waste to the designated pick-up location and it must accurately reflect the radioactive content. Terms such as "less than" or "trace" are unacceptable. If a laboratory group requires more radioactive waste tags, containers, or general help, please call EH&S at 310-825-5396.

TRANSFER FOR DISPOSAL

Prior to transfer, the exterior of each waste bag or container must be surveyed to ensure that they are free of contamination. Personal protective equipment (PPE) is not required when handling sealed radioactive material and wearing a lab coat and gloves outside of a hazardous materials laboratory while transporting radioactive waste to the pick-up location is a violation of UCLA Policy 905 (Appendix D). However, a lab coat, gloves, and safety glasses should be readily available in the unlikely event of a spill.

Radioactive waste must be taken to the nearest designated pick-up location within your building complex. The current EH&S waste pick-up schedule can be accessed at the EH&S website (*www.ehs.ucla.edu*). The waste should be delivered to the designated pick-up location in a timely manner and no stops should be made between the laboratory and the pick-up site, unless absolutely necessary. Freight elevators should be used if possible, and public elevators should be avoided in order to minimize unnecessary radiation exposure to the general public. The PI is responsible for ensuring that no member of the public receives a radiation dose greater than 2 mrem in any one hour and adequate shielding of the radioactive waste is required. Please contact EH&S for assistance with shielding radioactive waste containers during transportation to the pick-up location.

SPECIAL FACILITIES AND CONSIDERATIONS

In certain approved facilities, short-lived (less than 4 day half-life) radioactive waste is permitted to be stored for decay, rather than transferred to EH&S. These facilities and associated PIs have express, written approval from EH&S in the form of approved experimental protocols. If approved, the short-lived waste must be stored in appropriate, labeled containers that are shielded, if necessary. Clear signage must be in place to prevent unnecessary radiation exposure and improper disposal. After the waste has decayed to background levels (a minimum of 10 half-lives), the waste must be surveyed using an appropriate radiation detection instrument. If no counts above background are observed, the waste may be disposed of as non-radioactive, provided that all radioactive wording and/or labeling has been defaced or obliterated. Any other hazard contained in the waste must be addressed appropriately (e.g., biohazardous, corrosive) even though the radiation hazard has been eliminated. Only trained and authorized radiation workers are permitted to perform these actions. For more information regarding this process, contact EH&S at *radiationsafety@ehs.ucla.edu*.

Disposal of Generally Licensed Sources and Material

Certain radioactive materials and sources are able to be purchased directly by laboratories under general license regulations. While the radiological risks involved with these products are very low because of inherent safety features or low radioactive content, special precautions must be taken regarding their use and disposal. Upon receipt, the purchaser of the source or material is considered to be the "general licensee" and must comply with the requirements indicated on the product's label and MSDS.

LIQUID SCINTILLATION COUNTERS, GAS CHROMATOGRAPHS, AND STATIC ELIMINATORS

Certain equipment such as liquid scintillation counters, gas chromatographs (electron capture detectors), and static eliminators contain radioactive sources and the sources must be removed by the vendor or by EH&S prior to disposal. EH&S must be contacted to ensure proper disposal or transfer of the installed radioactive material. If the manufacturer of the equipment will be removing the installed sources, EH&S should be informed prior to the source removal.

URANIUM AND THORIUM COMPOUNDS

Some uranium and thorium compounds (e.g., uranyl acetate, uranyl nitrate, thorium nitrate) may be acquired and used under a general license. These compounds still pose a radioactive hazard if they are not used in accordance with the labeling instructions and MSDS. Additionally, any waste material must be disposed of in accordance with radioactive waste regulations. This material may not be disposed of in regular trash. Bring this material to the nearest radioactive waste pick-up site during the scheduled time or contact EH&S at (310) 825-5396 or *radiationsafety@ehs.ucla.edu* for pick-up of the waste.

Disposal of Empty Radioactive Material Shipping Containers

Empty radioactive material shipping containers (e.g., cardboard boxes) must be monitored for contamination before disposal as regular trash. Packaging with detectable radioactive contamination must **never** be disposed of in the regular trash. If contamination is found, isolate the area of the packaging and remove the affected area. Dispose of the contaminated packaging as radioactive waste. Re-scan or swipe the remaining packaging to ensure that all contamination has been removed. Before disposing of the packaging as regular trash, all radioactive material labels, symbols, and wording must be defaced or obliterated.

Noncompliance

Failure to adhere to all of the radioactive waste disposal procedures and requirements referenced in any UCLA or EH&S policies, or outlined in this chapter, may result in the following:

- Rejection of radioactive waste at the pickup location and return of radioactive waste to the laboratory for proper re-packaging.
- Issuance of verbal or written warning to the laboratory, followed by escalating enforcement which may include the issuance of a Strike One Memorandum in accordance with EH&S Radiation Safety Program's Three Strike Policy (Refer to Appendix D).

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Chapter 9: Receipt and Shipment of Radioactive Material

Introduction

Strict Federal and State regulations govern the receipt and shipment of radioactive material. Failure to adhere to these regulations can result in license violations and costly fees. EH&S has implemented radioactive material receipt, transfer, and shipment procedures to ensure regulatory compliance and safety during these processes.

Radioactive Material Receipt

Prior to ordering radioactive material, it is important to consider the following:

- Radioisotope shipment and possession limits
- Approved chemical forms
- Use limitations
- Shipping instructions
- Lead times

Figure 9.1 – Sample Shipping Label

> **Ship to:**
>
> UCLA Radiation Safety Office
> c/o Medical Receiving
> CHS A6-060C
> Attn: *(insert PI name)*
> LA: *(insert radiation permit number)*
> 650 Charles Young Drive South
> Los Angeles, CA 90095-1764

Radioisotope packages are received directly by the EH&S Radiation Safety Office located at the Center for Health Sciences (CHS), room A6-060C. Each radioisotope package is evaluated for damage, external radiation levels, external and internal contamination, and labeling compliance per state and federal regulations. Additionally, each waste package must conform to the current approved chemical forms and radioisotope limits listed on the receiving group's Radioactive Materials Permit. In the event that a radioactive material package is mistakenly delivered directly to the laboratory, EH&S must be contacted immediately at 310-825-5396.

All radioactive material packages **must be shipped directly to the Radiation Safety Office at CHS A6-060C** and must list the last name of the authorized PI and permit number in order to ensure prompt assignment and distribution. It is suggested that the format in Figure 9.1 be used.

Once evaluated, an inventory number (RSO number) will be assigned to each package. This number is used to easily reference radioisotope receipts. When the package is authorized for transfer to the permit holder, the group is notified using the laboratory phone number or e-mail address that is on file. Barring any receipt issues, this process is completed within a few hours of the package's delivery. The authorized laboratory group must send a trained radiation worker to retrieve the package during the EH&S Radiation Safety Office's normal business hours after notification of delivery. Radioactive material packages will only be released to radiation workers who provide picture identification.

RADIOACTIVE MATERIAL PACKAGE OPENING PROCEDURES

Although the EH&S Radiation Safety Office monitors all radioactive material packages for external radiation fields as well as external and internal contamination prior to transfer to the laboratory group, safe opening procedures must be utilized when opening the packaging and removing the stock vial container.

Guidelines for Opening RAM Packages

- ✓ Always open radioactive material packages in a dedicated radioactive material use area
- ✓ Always wear proper personal protective equipment (i.e., lab coat, gloves, safety glasses) when opening radioactive material packages
- ✓ Survey your hands and work area frequently
- ✓ Scan all external packaging for contamination and deface all labels before disposing as regular waste
- ✓ Survey stock vial containers frequently while in storage using swipes

All radioactive material packages must be opened in a designated radioactive material work area that is properly labeled and equipped with appropriate radiation detection equipment, shielding, waste containers, secondary containment, and remote handling tools (as necessary). Prior to opening the package, the worker must ensure that they are wearing proper personal protective equipment (PPE) including a laboratory coat, gloves, and appropriate safety eyewear. Once the package has been opened and the stock vial has been removed, the external packaging must be surveyed for contamination using a radiation detection meter or liquid scintillation counter, as appropriate. If no contamination is present, all radioactive labeling and wording must be defaced or obliterated prior to disposal as regular trash.

While in inventory, the outer containers of stock vials, commonly called “pigs”, should be swiped frequently to ensure that contamination is not present. If contamination is found, care should be taken to protect oneself from potential external exposure while removing the contamination. If a non-contaminated stock vial container is available, it is recommended that the vial be transferred and that the contaminated stock vial be disposed of as radioactive waste. It should always be assumed that the stock vial itself is contaminated.

RADIOACTIVE MATERIAL INVENTORY RECORDS

Each inventory record (RSO) number must be listed on a Radioactive Material Inventory form which is audited during EH&S radiation safety inspections. This form may be found in the Radiation Safety Journal or may be downloaded electronically by visiting *www.ehs.ucla.edu*. The PI (or qualified designee) is responsible for completing this form for each shipment of radioactive material received. The form should be filled out as soon as the laboratory group has received the isotope, regardless of when it will be used. Each time the isotope is used, the inventory record must be updated. When the stock vial is depleted, or the material is no longer of any use, complete the inventory record by indicating the disposal date and initials of the person disposing of the material. Always deface or obliterate any radioactive markings or wording on the stock vial prior to disposal as radioactive waste.

ON-CAMPUS TRANSFERS OF RADIOACTIVE MATERIAL

Exceptions to the radioactive material shipment requirements must be expressly approved by EH&S. However, the transfer of isotopes from one authorized PI to another can be made within the limits specified in the recipient's Radioactive Materials Permit. The transfers must be documented by completing a Radioactive Material Transfer Record. This form may be found in the RSJ or may be downloaded electronically by visiting *www.ehs.ucla.edu*.

Cyclotron-Produced Radioisotopes

Cyclotron-produced radioisotopes and labeled compounds manufactured at UCLA may be approved for direct transfer to authorized permit holders without being routed through the EH&S Radiation Safety Program. Direct transfers must be approved by EH&S. The transfer of cyclotron-produced radioisotopes and labeled compounds must be made within the quantity limits specified in the transferor's and recipient's permits, and must be documented. Before initiating such a transfer, the transferring PI must confirm that the recipient is authorized to receive the radioisotopes and/or labeled compounds and that the quantity to be transferred is within the approved limits. Contact EH&S for more information regarding cyclotron-produced radioisotope transfers.

GENERALLY LICENSED RADIOACTIVE MATERIAL AND SOURCES

Some small quantities of radioactive material are permanently installed in commercially-available devices, such as military compasses, luminescent exit signs, liquid scintillation counters, gas chromatographs (electron capture detectors), and static eliminators. While these sources are exempt from ordinary controls because of general license provisions in Title 17 of the California Code of Regulations (CCR), their acquisition and description must be reported to EH&S. Many of these sources require semi-annual leak testing that must be performed by the Radiation Safety Program.

Additionally, many naturally occurring (NORM) forms of uranium and thorium isotopes are received directly by the laboratory as generally licensed material. Refer to the MSDS prior to opening and handling this material and ensure that personnel are trained on the hazards involved. All waste material must be disposed of as radioactive waste. Disposal of these items must be coordinated through EH&S.

For all generally licensed material and sources, refer to the product labeling and MSDS (when applicable) for handling and disposal instructions, in addition to any other requirements.

Radioactive Material Shipments

The shipment of radioactive material from an authorized PI to another licensee outside of UCLA is subject to strict Federal Department of Transportation (DOT) regulations and requirements. The EH&S Radiation Safety Office is the **only** organization at UCLA that can ship radioactive material to off-campus locations. If an off-campus shipment is required, the PI should contact EH&S and supply the following:

- Radioisotope, chemical form, activity, and volume
- Recipient's shipping address and current radioactive material license. This license is required to confirm that the recipient is authorized to receive the radioisotope
- Packing materials, including dry ice, if applicable (contact your designated health physicist for packaging guidelines)

- Recharge number for shipping costs

The preparation of an off-campus radioactive materials shipment is involved and sufficient time should be given to EH&S to allow for the processing. A minimum of three business days is preferred.

Chapter 10: Personnel Radiation Monitoring

Introduction

Personnel monitoring, or dosimetry, involves the measurement and interpretation of worker exposure to radiation sources. It is the responsibility of EH&S to provide external and internal monitoring for those who meet the requirements listed in this chapter. Whole body dosimeters are used to estimate the deep dose equivalent (DDE), lens dose equivalent (LDE), and shallow dose equivalent (SDE) received by an individual when exposed to sources of radiation external to the body; ring dosimeters may be used if the radiation dose to the hands is expected to be significantly higher than the radiation dose to the whole body. Bioassays are used to estimate the committed dose equivalent (CDE) and committed effective dose equivalent (CEDE) received by an individual from radioisotopes deposited in the body through inhalation or ingestion.

External Dosimetry Program

The purpose of the external dosimetry program is to provide occupational workers with an estimate of their radiation dose. In order to provide an accurate exposure record and prevent invalid dosimeter readings, the following guidelines should be followed:

Do's and Don'ts of Dosimetry

Do	Don't
• The dosimeter or badge must be worn only during periods of occupational exposure. • Exchange your dosimeter at the predetermined time. • Wear your whole-body badge on the front of your body, between the neck and waist, preferably at the collar. If a lead apron is worn, wear the badge outside the apron. The badge must be facing outwards, toward the source of exposure. • Wear only your assigned dosimeter. • Wear ring badges with the label side facing the source of exposure. Ring badges should be worn underneath gloves.	• Do **NOT** wear the dosimeter or badge away from the workplace • Do **NOT** wear your dosimeter when you receive personal medical imaging, dental, or nuclear medicine examinations. • Do **NOT** tamper with or unnecessarily expose a dosimeter to radiation. • Do **NOT** send your dosimeter through the clothes washer or dryer. • Do **NOT** wear any other individual's dosimeter. • Do **NOT** store your radiation badge near a radiation source. For example, do not leave it attached to a lead apron that will be stored in the x-ray examination room.

Area monitoring dosimeters are used to evaluate exposure from x-ray, gamma ray, and neutron activity in a specific work area. Personnel dosimeters should not be used as area monitors. Please contact EH&S for more information regarding area monitors.

EXTERNAL DOSIMETRY REQUIREMENTS

External dosimetry requirements can be found in the California Code of Regulations (CCR), Title 17 and are summarized in Table 10.1.

Table 10.1 – Adult External Occupational Dose Limits

Dose Term	Dose Limit
Total Effective Dose Equivalent (TEDE) (whole-body [1] dose from both external and internal sources)	5 rem (5,000 mrem)/yr
Lens Dose Equivalent (LDE) (dose to the lens of the eye)	15 rem (15,000 mrem)/yr
Shallow Dose Equivalent (SDE) (Skin and Extremity dose)	50 rem (50,000 mrem)/yr
Total Organ Dose Equivalent (TODE) (The organ receiving the highest dose from both external and internal sources)	50 rem (50,000 mrem)/yr
Minors	0.5 rem (500 mrem)/yr
Declared Pregnant Woman	0.5 rem (500 mrem) for the entire pregnancy

[1] Whole-body means, for purposes of external exposure, head, trunk, arms above the elbow, or legs above the knee.

State regulations require that personnel dosimeters be worn under the following working conditions:

- Adults who are likely to receive in one year (from sources external to the body), a dose in excess of 10% of any occupational dose limit.
- Minors (<18 years of age) are allowed to receive 10% of the annual occupational dose limits specified for adult workers and must be provided dosimeters if likely to receive in one year (from sources external to the body) a deep dose equivalent in excess of 0.1 rem, a lens dose equivalent in excess of 0.15 rem, or a shallow dose equivalent to the skin or to the extremities in excess of 0.5 rem.
- Declared pregnant women likely to receive during the entire pregnancy (from sources external to the body), a deep dose equivalent in excess of 0.1 rem.
- Individuals who enter a high or very high radiation area.
- All individuals who operate mobile x-ray equipment.

In addition to the dosimetry requirements listed in Table 10.1, EH&S has implemented the following guidelines in Table 10.2 to assist researchers in determining whether individuals should be monitored for external radiation exposure:

Table 10.2 – UCLA Dosimetry Trigger Limits

Radionuclide	Trigger	Dosimeter Type
High energy beta emitters	≥ 300 mCi annual purchase limit	Whole body dosimeter
High energy beta emitters	≥ 10 mCi/experiment or shipment	Finger ring dosimeter
I-125	≥ 1 mCi/experiment or shipment	Whole body dosimeter
Iodination (I-125/I-131)	≥ 1 mCi/experiment or shipment	Whole body dosimeter and finger ring dosimeter
Cr-51	≥ 1 mCi/experiment or shipment	Whole body dosimeter and finger ring dosimeter
PET radionuclides	≥ 2 mCi/experiment or shipment	Whole body dosimeter, left and right finger ring dosimeters

It is the responsibility of the Principal Investigator (PI) to review the dosimetry trigger limits, determine whether dosimetry is required for their staff, and inform EH&S. EH&S will not issue dosimetry to an individual without evidence of appropriate radiation safety training. See *Chapter 4: Training* for specific training requirements. Contact your assigned health physicist directly or EH&S via e-mail at *radiationsafety@ehs.ucla.edu* with any questions regarding external dosimetry.

TYPES OF DOSIMETERS

There are two primary types of dosimeters used at UCLA:

- Luxel® whole body badges; and
- Thermoluminescent Dosimeter (TLD) finger rings.

Luxel® dosimeters utilize optically stimulated luminescence technology. When exposed to ionizing radiation fields, the crystalline detector material traps and stores energy. The amount of exposure can be determined by stimulating the crystalline material with a green light and measuring the intensity of the blue light emitted. Thermoluminescent dosimeters are crystalline solids that trap electrons when exposed to ionizing radiation. Upon heating, the amount of light emitted is proportional to radiation exposure.

DOSIMETRY EXCHANGE

Badges are issued by EH&S on either a monthly or quarterly basis, depending on the type of radiation handled and the frequency of use. Badges will be sent to department representatives on or about the 20th of the month. The department representatives are responsible for distributing the badges to their respective labs. The previous month's badges must be returned by the seventh working day of the new month.

LATE OR LOST DOSIMETERS

External dosimeters are considered late if they are not returned to EH&S by the seventh working day of the month following the wear period. A notice listing the late dosimeters will be sent to a department representative. If dosimeters are not turned in by the due date, a late fee may be assessed. If you have lost your dosimeter, please contact EH&S.

EXTERNAL DOSE-EQUIVALENT ESTIMATION FOR LOST BADGES

A lost (non-returned) dosimeter causes a permanent gap in the individual's exposure history record. With the concurrence of the California Department of Public Health (CDPH), EH&S, and the affected individual will work together to assign a realistic dose for the delinquent period of time.

ALARA LIMITS

All laboratories using any form of ionizing radiation at UCLA (e.g., radioisotopes, radiation-producing machines, and cyclotrons) are expected to follow the radiation safety principle of ALARA, an acronym for "as low as reasonably achievable". This principle implies the search for a balance between maximizing the benefit and reasonably minimizing risks associated with ionizing radiation. EH&S uses ALARA dose limits to keep exposures well below the regulatory limits.

The Radiation Safety Committee has approved the following ALARA limits in Table 10.3:

Table 10.3 – ALARA Limits Table

Dosimetry Type	ALARA I Limit	ALARA II Limit	ALARA III Limit
Whole-body (monthly)	100 mrem	200 mrem	400 mrem
Whole-body (quarterly)	300 mrem	800 mrem	1,200 mrem
Extremity/Shallow (monthly)	1,000 mrem	2,000 mrem	4,000 mrem
Extremity/Shallow (quarterly)	3,000 mrem	6,000 mrem	12,000 mrem
Lens of Eye (monthly)	300 mrem	600 mrem	1,200 mrem
Lens of Eye (quarterly)	900 mrem	1,800 mrem	3,600 mrem
Declared pregnant woman (monthly)	12 mrem	24 mrem	48 mrem

EH&S is notified when individuals exceed the ALARA I limit. These notifications are reviewed and kept on file for future analysis.

Individuals who exceed the ALARA II limits on either a monthly or quarterly basis receive a Report of Unusual Radiation Exposure (RURE) from EH&S. The purpose of this report is to notify the individual that their dose has exceeded the ALARA II limit, but has not yet exceeded occupational dose limits. Individuals are required to complete the ALARA questionnaire attached to the report. The questionnaire helps EH&S determine if additional training is required and if safe operating procedures, administrative controls, or engineered safeguards are appropriate for the work performed.

Individuals who exceed the ALARA III limit are likely to exceed occupational dose limits. In addition to issuing a Report of Unusual Radiation Exposure and ALARA questionnaire, the EH&S staff will work with the individual to determine what changes, if appropriate, can be made to reduce the worker's overall exposure.

EVALUATION OF EXPOSURE HISTORY REPORTS

EH&S health physicists evaluate monthly and quarterly exposure history reports to determine exposure trends, accuracy of doses, and to identify doses to individuals that exceed any of the ALARA limits. Personnel exposure histories are a legal record of the individual's occupational exposure at UCLA. It is important that there are no gaps in monitoring service and that all badges are turned in on a timely basis.

Permanent exposure history records, in the form of hard-copy documents, are maintained by EH&S for all individuals assigned personal dosimetry. Exposure reports are normally distributed to individuals through a department representative; however, EH&S will provide these records individually upon request.

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH NOTIFICATION

In compliance with State regulations, UCLA is required to notify the California Department of Public Health (CDPH) in cases where an individual has received a dose in excess of any of the occupational dose limits as indicated in Table 10.4:

Table 10.4 – Notification of Incidents Requirements

Dose Term	Immediate Notification	Twenty-four Hour Notification
Total Effective Dose Equivalent (TEDE)	≥ 25 rem	>5 rem <25 rem
Lens Dose Equivalent (LDE)	≥ 75 rem	>15 rem <75 rem
Shallow Dose Equivalent (SDE)	≥ 250 rad	> 50 rem < 250 rad
Individual Intake	5 times the annual limit for intake	Excess of one occupational annual limit

In addition to the notification of incidents, the CDPH requires that a written report be submitted by the licensee/registrant within thirty days after learning of an overexposure. The report must include estimates of each individual's dose, concentration of radioisotope involved (as applicable), the circumstances under which the exposure occurred, and the corrective action taken or planned to ensure against a recurrence.

Personnel Monitoring for Internal Radiation Exposure

The term "bioassay" refers to the assessment of radioisotope intake and deposition in the worker's body. The type and quantity of radioisotope is determined by *in vivo* counting or *in vitro* measurement of radioisotopes excreted or removed from the body.

EH&S staff perform and evaluate thyroid and urine bioassays. The need for monitoring individual workers is determined by the type and quantity of radioactive material handled, survey measurements, and the effectiveness of safeguards.

INTERNAL DOSIMETRY REQUIREMENTS

Bioassay measurements are used to confirm the adequacy of radiological controls and determine compliance with the occupational dose limits.

Internal dosimetry requirements can be found in California Code of Regulations (CCR) Title 17 and are summarized in Table 10.5:

Table 10.5 – Adult Internal Occupational Dose Limits

Dose Term	Dose Limit
Committed Dose Equivalent (CDE) (Dose received by an internal organ from material deposited inside the body)	50 rem (50,000 mrem)/year
Committed Effective Dose Equivalent (CEDE) (Dose received by the whole-body from material deposited inside the body)	5 rem (5,000 mrem)/year

INTERNAL DOSIMETRY TRIGGERS

EH&S has implemented the following guidelines in Table 10.6 to assist researchers in determining whether individuals should be monitored for internal radiation exposure:

Table 10.6 – Standard Trigger Thresholds for Bioassay

Radionuclide	Trigger	Requirement
Beta emitters (other than ^{3}H)	≥20 mCi per experiment or shipment	Urine bioassay
^{3}H	≥40 mCi per experiment or shipment	Urine bioassay
^{123}I /^{124}I/^{125}I/^{131}I (unbound)	≥1 mCi/experiment or shipment	Thyroid bioassay

It is the responsibility of the PI to review the bioassay trigger limits, determine whether a bioassay is required for their staff, and inform EH&S.

Thyroid Bioassay

For non-human research operations, the use of unbound I-123, I-124, I-125 or I-131 sources in an open room or on a laboratory bench is prohibited. All procedures with a potential for producing airborne radioactivity, including the opening of sealed bottles or storage containers holding more than 0.1 mCi of I-123, I-124, I-125 or I-131, should be done in an approved fume hood having a face velocity of at least 100 linear feet per minute (ft/min). The use of either an approved fume hood or a special iodination hood is required as a condition of any radioactive materials permit utilizing unbound radioiodines.

A thyroid bioassay is required when any individual handles 1 mCi (or more) of unbound radioactive iodine. Thyroid bioassays are **not** required when an individual handles radioimmunoassay kits (RIA) or stabilized radioiodine compounds.

Frequency

For individuals who meet the above criteria for handling I-123, thyroid bioassays should be performed within 24 hours after each use. For I-124, I-125, and I-131, thyroid bioassays should be performed within 48 to 72 hours after each use. If radioactive iodine is handled multiple times over the course of several weeks, only one thyroid bioassay should be performed per week. Handling includes the opening of a supply container as well as the removal of a working quantity.

Investigation Level

A follow-up bioassay will be conducted if a positive thyroid bioassay results in a measured activity of 1% or greater of the applicable Annual Limit on Intake (ALI) (1% of the ALI leads to a committed effective dose equivalent of 50 mrem). If the original measurement is confirmed, the following steps may be invoked:

- The bioassay procedure will be repeated on a weekly basis until the thyroid measurement shows a reduction to less than 1% of the applicable Annual Limit on Intake.
- The iodine work area and handling procedures will be evaluated by EH&S and the PI will be required to identify and implement corrective actions.
- A worker's potential for receiving additional radiation exposure may be limited, as necessary.

Urine Bioassay

Urine bioassay measurements are conducted to assess the type and quantity of radioisotope deposited in the body. At UCLA, urinalysis is commonly used to measure the internal radiation exposure from beta-emitting isotopes such as H-3, C-14, P-32, S-35, Ca-45, or Cl-36 in activities in excess of the trigger thresholds.

A urine bioassay is required when an individual handles 40 mCi (or more) of tritium or 20 mCi (or more) of a beta-emitting radioisotope other than tritium.

Frequency

For individuals who meet the above criteria for handling beta-emitting radioisotopes, urine bioassays should be performed within 24 to 48 hours after each use. If a beta-emitting radioisotope (in excess of the trigger limits) is handled multiple times over the course of several weeks, only one urine bioassay should be performed per week. Handling includes the opening of a supply container as well as the removal of a working quantity.

Investigation Level

A follow-up bioassay will be conducted if a positive urine bioassay results in a measured activity of 1% or greater of the applicable Annual Limit on Intake (1% of the ALI leads to a committed effective dose equivalent of 50 mrem). When follow-up urine bioassay measurements indicate an intake equal to, or in excess of, the investigation level, the following steps will be taken:

- The bioassay procedure will be repeated on a weekly basis until the urine measurement shows a reduction to less than 1% of the applicable Annual Limit on Intake.
- The radioactive material work area and handling procedures will be evaluated by EH&S and the PI will be required to identify and implement corrective actions.

- A worker's potential for receiving additional radiation exposure may be limited, as necessary.

Fecal Bioassay

Fecal bioassay measurements are conducted to assess the type and quantity of alpha-emitting radioisotopes deposited in the body. Since alpha-emitters are rarely used at UCLA, EH&S will evaluate the need for a bioassay on a case-by-case basis.

Declared Pregnant Woman Program

When a woman is pregnant and her abdomen is exposed to sufficiently penetrating radiation from either external or internal radiation sources, her unborn child will also be exposed to radiation. A fetus is more sensitive to radiation than the adult because of its rapid rate of development. At certain times during development, those cells forming a specific organ or body function are dividing very rapidly and therefore are most likely to be damaged. Very large doses of radiation (greater than 100 rem) to unborn children can cause growth retardation, severe birth defects, and even death. The specific organ most seriously affected by radiation depends on the stage of growth at the time of the exposure. For growth defects, the period of greatest sensitivity is between weeks eight and twelve of a woman's pregnancy.

DECLARING A PREGNANCY

It is critical that female radiation workers who are, or wish to become, pregnant declare their pregnancy to EH&S so fetal monitoring may be implemented. This is a voluntary, personal decision that may be made only by the worker herself. The employer may not declare a pregnancy for a female radiation worker.

Declaring a pregnancy, or the potential for pregnancy, is documented in writing by the woman and the declaration is kept confidential by EH&S. Fetal monitoring dosimetry badges may be sent directly to the declared pregnant woman on a monthly basis, rather than to a department representative for distribution. The dosimeters are then returned directly to EH&S by the declared pregnant woman.

FETAL EXPOSURE LIMITS AND RISK

Federal regulations require that the dose to an embryo/fetus during the entire pregnancy from occupational exposure of a declared pregnant woman not exceed 500 mrem (0.5 rem). The dose to the embryo/fetus is calculated by summing:

- The deep dose equivalent to the declared pregnant woman; and
- The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

Each woman must decide whether the radiation risks to her unborn child are acceptable. The following facts may aid decision making:

- The first three months of pregnancy are the most important in gestation. An unborn child is more sensitive to radiation than an adult because of its rapid rate of development. The decision should be made early as to whether a pregnant woman will continue to work in areas/departments exposed to radiation.

- Due to body shielding, the actual radiation dose received by an unborn child will be less than that to the woman in most work situations. At UCLA, most occupational exposures are well below the radiation limits recommended for prenatal exposure.
- The radiation dose to the unborn child can be reduced by decreasing the amount of time spent in a radiation work area, increasing the distance from the source of radiation, or by shielding the source itself.
- Occupational and prenatal radiation exposure limits are set at very conservative levels where there has been no scientific evidence of adverse biological effects.

Please contact your assigned health physicist directly, or EH&S at *radiationsafety@ehs.ucla.edu*, with any questions regarding the declared pregnant woman program or to receive additional information regarding radiation exposure in utero.

Additional Information

Individuals who do not meet the above indications for external or internal monitoring may request to participate in either program as desired by contacting EH&S.

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Chapter 11: Environmental Monitoring

Introduction

Environmental monitoring is used at UCLA to ensure that radiation exposure to members of the public are maintained within the limits established by State and Federal regulations.

Control and Monitoring of Radioactive Discharges from Potential Release Locations

There are three primary pathways through which members of the public could potentially receive levels of ionizing radiation exposure above background levels:

1. Liquid effluent releases;
2. Air effluent releases; and
3. Exposure to penetrating radiation such as x-rays, gamma rays, and neutrons.

LIQUID EFFLUENT RELEASE

Discharge of radioactive material to surface waters, sewers, and groundwater is strictly prohibited in laboratories at UCLA. All liquid radioactive material generated at UCLA is disposed of through licensed facilities as radioactive waste.

AIR EFFLUENT RELEASE

Certain laboratory procedures can lead to the release of radioactive materials into the air. Expected levels of airborne concentrations of an isotope or a mixture of isotopes must be evaluated carefully. EH&S uses inventory controls and continuous stack monitoring of the cyclotron facilities to ensure that members of the public will not be expected to receive a radiation dose in excess of 10 millirem per year from air emissions.

- **Radioactive Material Inventory Control**

  All radioactive material ordered by Principal Investigators (PIs) must be shipped directly to the EH&S Radiation Safety Office. As a result, EH&S is able to determine the total quantity of each radioisotope used at UCLA and periodically reviews this information to ensure compliance with Nuclear Regulatory Commission (NRC) and Environmental Protection Agency (EPA) regulations.

- **Cyclotron Monitoring**

  Cyclotrons are dedicated to the production of C-11, N-13, O-15 and F-18 for use in various chemical forms in positron emission tomography (PET) for research and clinical applications. Effluent releases are continuously monitored with radiation monitoring instruments, and historical measurements indicate that airborne concentrations are well below regulatory limits.

EXTERNAL EXPOSURE TO IONIZING RADIATION

EH&S assesses external radiation exposure to members of the general public by placing area monitors near significant sources of radiation. Results of the area monitors are reviewed by EH&S on either a monthly or quarterly basis to ensure that radiation exposures to members of the general public are maintained below regulatory limits. For new construction or remodeling of existing radiation areas, the PI is responsible for evaluating the adequacy of shielding; a shielding evaluation report must be submitted to and approved by EH&S before beginning construction activities. If additional shielding is required, the installation of shielding material must be verified and approved; a shielding verification report must be submitted to and approved by EH&S before radioactive material and/or radiation-producing machines can be used in the area.

Chapter 12: Compliance

Introduction

Laboratory activities must be conducted so as to prevent unnecessary radiation exposure and must conform to UCLA's radioactive material license, applicable regulations, and best industry practices. These requirements include demonstration of the ALARA principle in the laboratory setting and establishment, maintenance, and auditing of procedures and records pertaining to the use of radioactive material or radiation-producing machines.

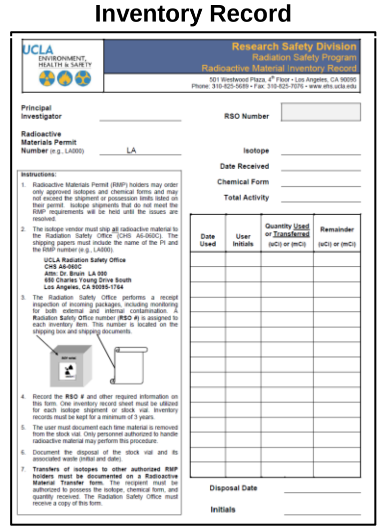
Procedures

When submitting an experimental procedure for approval by EH&S, the PI is responsible for ensuring that all radiation safety requirements are met and demonstrated in the procedure. Procedures should contain the following radiation safety considerations before submission to EH&S for approval:

1. Compliance with the UCLA Personal Protective Equipment (PPE) Policy 905
2. No food or drink in radioactive material use labs at any time
3. Proper storage, shielding (if necessary), and security of radioactive material and radiation-producing machines
4. Proper documentation of radioactive material inventory and radiation-producing machines
5. All work with volatile material to be done in a certified radioactive material use fume hood
6. Proper surveying of equipment and radioactive material work areas with swipe testing and an appropriate calibrated survey meter (if applicable)
7. Personal dosimetry (if applicable) to be worn during radiation work
8. Monitoring personnel with an appropriate survey meter during and after radioactive material use
9. Proper disposal of radioactive waste
10. Secondary containment of liquids
11. Washing of hands prior to work breaks

It is highly recommended that the Principal Investigator (PI), or a qualified designee, audit these procedures on an annual basis to ensure that all work being performed is consistent with what was approved by EH&S. Changes to procedures must be documented on an as needed basis and EH&S should be notified as soon as the changes are effective.

Figure 12.1: Radioactive Material Inventory Record



UCLA ENVIRONMENT, HEALTH & SAFETY

Research Safety Division
Radiation Safety Program
Radioactive Material Inventory Record

501 Westwood Plaza, 4th Floor • Los Angeles, CA 90095
Phone: 310-825-5689 • Fax: 310-825-7076 • www.ehs.ucla.edu

Principal Investigator ____ RSO Number ____

Radioactive Materials Permit Number (e.g., LA000) LA____

Isotope ____

Date Received ____

Chemical Form ____

Total Activity ____

Instructions:

1. Radioactive Materials Permit (RMP) holders may order only approved isotopes and chemical forms and may not exceed the shipment or possession limits listed on their permit. Isotope shipments that do not meet the RMP requirements will be held until the issues are resolved.
2. The isotope vendor must ship all radioactive material to the Radiation Safety Office (CHS A6-060C). The shipping papers must include the name of the PI and the RMP number (e.g., LA000).

   UCLA Radiation Safety Office
   CHS A6-060C
   Attn: Dr. Bruin LA 000
   650 Charles Young Drive South
   Los Angeles, CA 90095-1764

3. The Radiation Safety Office performs a receipt inspection of incoming packages, including monitoring for both external and internal contamination. A Radiation Safety Office number (**RSO #**) is assigned to each inventory item. This number is located on the shipping box and shipping documents.
4. Record the **RSO #** and other required information on this form. One inventory record sheet must be utilized for each isotope shipment or stock vial. Inventory records must be kept for a minimum of 3 years.
5. The user must document each time material is removed from the stock vial. Only personnel authorized to handle radioactive material may perform this procedure.
6. Document the disposal of the stock vial and its associated waste (initial and date).
7. **Transfers of isotopes to other authorized RMP holders must be documented on a Radioactive Material Transfer form.** The recipient must be authorized to possess the isotope, chemical form, and quantity received. The Radiation Safety Office must receive a copy of this form.

Date Used	User Initials	Quantity Used or Transferred (uCi) or (mCi)	Remainder (uCi) or (mCi)

Disposal Date ____

Initials ____

RADIOACTIVE MATERIAL INVENTORY RECORDS

The PI, or a qualified designee, is responsible for completing a Radioactive Material Inventory Record (Figure 12.1) for each shipment of radioactive material received. The form should be completed as soon as the laboratory group has received the isotope, regardless of when it will be used. A separate entry should be made each time radioactive material is withdrawn from the stock container. Once all radioactive material from a given shipment has been used and disposed of, the bottom of the inventory form should be initialed and dated.

RADIATION-PRODUCING MACHINE INVENTORY

The PI, or qualified designee, is responsible for notifying EH&S of the acquisition, disposal, or transfer of any radiation-producing machine in a timely manner. EH&S registers each radiation-producing machine with the California Department of Public Health (CDPH) on behalf of the PI and verifies the current status of this inventory during annual audits. Equipment that is found to be out of compliance with current regulations or in inoperable condition will be locked-out using a tagging system and indicated as such on the associated Radiation-Producing Machine Permit. Removing a lock-out tag is prohibited without approval from EH&S.

SECURITY OF RADIOACTIVE MATERIALS AND RADIATION-PRODUCING MACHINES

To prevent the loss or misuse of radioactive material or radiation-producing machines, the following security measures should be followed:

1. Keep all doors to radioactive material and radiation-producing machine laboratories locked when the rooms are unattended.
2. Store radioactive material in locked containers.
3. Challenge unknown individuals in the laboratory; ask for identification.
4. Provide for constant supervision of all radiation use areas within the laboratory, while the area is occupied by personnel.

FOOD AND DRINK IN THE LABORATORY

To prevent the accidental ingestion of hazardous materials, food and drink may not be consumed in a hazardous material use laboratory. The EH&S Radiation Safety Office has implemented a Radioactive Material Use Laboratory Food and Drink Policy that may be referenced in Appendix D.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment is important in keeping a safe work environment. Accordingly, all laboratory groups must abide by UCLA Policy 905. When entering a radioactive materials laboratory, long pants (or equivalent) and closed-toed shoes must be worn. When working with radioactive material, appropriate lab coats, gloves, and safety glasses must be worn.

FUME HOODS AND BIOSAFETY CABINETS

Fume hoods and biosafety cabinets must be certified annually. If a fume hood is inoperable or will not be used for hazardous materials work, contact EH&S for the appropriate signage.

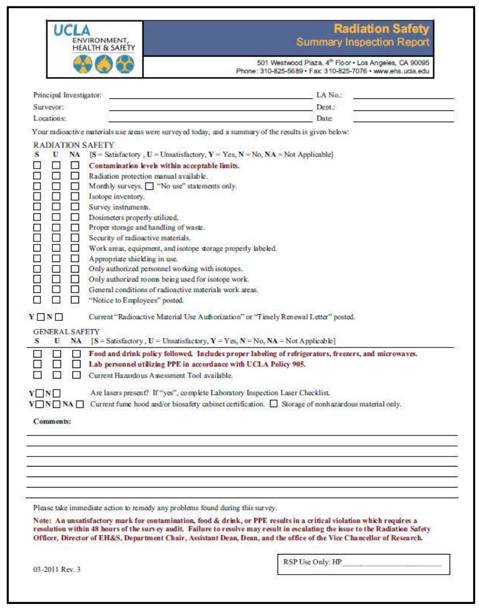
Inspections

EH&S conducts quarterly, semi-annual, or annual routine inspections of all Radioactive Materials Permits and Radiation-Producing Machine Permits in addition to follow-up inspections, when necessary. Laboratory commissioning and clearance inspections are performed on a case-by-case basis. Routine inspection frequency is based on considerations such as the safety index value, the quantity and type of radioisotopes or radiation-producing machines in use, recent laboratory radiation safety performance, and worker exposure status as reflected by dosimetry badge and/or bioassay results.

RADIOACTIVE MATERIALS USE PERMIT ROUTINE INSPECTIONS

Although all EH&S radiation safety inspections will evaluate the general radiation safety performance of a laboratory, special attention will be paid to the following areas when performing routine inspections of Radioactive Material Use Permits:

Figure 12.2: Radioactive Materials Use Permit –Summary Inspection Report


UCLA ENVIRONMENT, HEALTH & SAFETY

Radiation Safety
Summary Inspection Report

501 Westwood Plaza, 4th Floor • Los Angeles, CA 90095
Phone: 310-825-5689 • Fax: 310-825-7076 • www.ehs.ucla.edu

Principal Investigator: ______ LA No.: ______
Surveyor: ______ Dept.: ______
Locations: ______ Date: ______

Your radioactive materials use areas were surveyed today, and a summary of the results is given below:

RADIATION SAFETY

S U NA [S = Satisfactory , U = Unsatisfactory, Y = Yes, N = No, NA = Not Applicable]

☐ ☐ ☐ **Contamination levels within acceptable limits.**
☐ ☐ ☐ Radiation protection manual available.
☐ ☐ ☐ Monthly surveys. ☐ "No use" statements only.
☐ ☐ ☐ Isotope inventory.
☐ ☐ ☐ Survey instruments.
☐ ☐ ☐ Dosimeters properly utilized.
☐ ☐ ☐ Proper storage and handling of waste.
☐ ☐ ☐ Security of radioactive materials.
☐ ☐ ☐ Work areas, equipment, and isotope storage properly labeled.
☐ ☐ ☐ Appropriate shielding in use.
☐ ☐ ☐ Only authorized personnel working with isotopes.
☐ ☐ ☐ Only authorized rooms being used for isotope work.
☐ ☐ ☐ General conditions of radioactive materials work areas.
☐ ☐ ☐ "Notice to Employees" posted.

Y ☐ N ☐ Current "Radioactive Material Use Authorization" or "Timely Renewal Letter" posted.

GENERAL SAFETY

S U NA [S = Satisfactory , U = Unsatisfactory, Y = Yes, N = No, NA = Not Applicable]

☐ ☐ ☐ **Food and drink policy followed. Includes proper labeling of refrigerators, freezers, and microwaves.**
☐ ☐ ☐ **Lab personnel utilizing PPE in accordance with UCLA Policy 905.**
☐ ☐ ☐ Current Hazardous Assessment Tool available.

Y ☐ N ☐ Are lasers present? If "yes", complete Laboratory Inspection Laser Checklist.
Y ☐ N ☐ NA ☐ Current fume hood and/or biosafety cabinet certification. ☐ Storage of nonhazardous material only.

Comments:

Please take immediate action to remedy any problems found during this survey.

Note: An unsatisfactory mark for contamination, food & drink, or PPE results in a critical violation which requires a resolution within 48 hours of the survey audit. Failure to resolve may result in escalating the issue to the Radiation Safety Officer, Director of EH&S, Department Chair, Assistant Dean, Dean, and the office of the Vice Chancellor of Research.

03-2011 Rev. 3

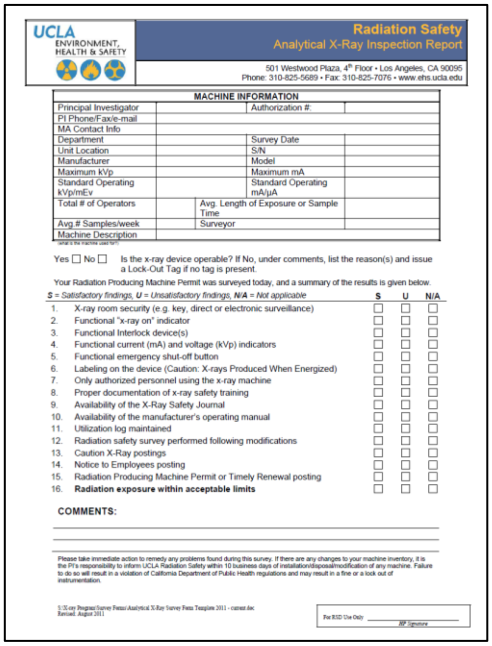
RSP Use Only: HP______

1. Presence of radioactive contamination
2. Monthly survey record availability
3. Inventory record availability
4. Survey instrument calibration and availability
5. Proper utilization of dosimetry, if issued
6. Proper storage and handling of radioactive waste
7. Security of radioactive materials
8. Proper labeling of radioactive material work areas, equipment, and isotopes
9. Authorized personnel working with radioactive materials
10. Authorized rooms used for radioactive material work
11. Current permit posting and/or "Timely Renewal Letter" posted
12. Adherence to food and drink policy, including the proper labeling of refrigerators, freezers, and microwaves
13. Adherence to UCLA Policy 905, including the proper utilization of personal protective equipment
14. Availability of the Radiation Safety Manual and required records
15. Availability of Laboratory Hazardous Assessment Tool
16. Fumes hood and biosafety cabinet certification

RADIATION-PRODUCING MACHINE PERMIT ROUTINE INSPECTIONS

During routine Radiation-Producing Machine Permit inspections, the following items will be evaluated, in addition to general radiation safety performance:

Figure 12.3: Radiation-Producing Machine Permit – Inspection Report



UCLA ENVIRONMENT, HEALTH & SAFETY

Radiation Safety
Analytical X-Ray Inspection Report

501 Westwood Plaza, 4th Floor • Los Angeles, CA 90095
Phone: 310-825-5689 • Fax: 310-825-7076 • www.ehs.ucla.edu

MACHINE INFORMATION			
Principal Investigator		Authorization #:	
PI Phone/Fax/e-mail			
MA Contact Info			
Department		Survey Date	
Unit Location		S/N	
Manufacturer		Model	
Maximum kVp		Maximum mA	
Standard Operating kVp/mEv		Standard Operating mA/µA	
Total # of Operators		Avg. Length of Exposure or Sample Time	
Avg.# Samples/week		Surveyor	
Machine Description (what is the machine used for?)			

Yes ☐ No ☐ Is the x-ray device operable? If No, under comments, list the reason(s) and issue a Lock-Out Tag if no tag is present.

Your Radiation Producing Machine Permit was surveyed today, and a summary of the results is given below.

S = Satisfactory findings, U = Unsatisfactory findings, N/A = Not applicable	S	U	N/A
1. X-ray room security (e.g. key, direct or electronic surveillance)	☐	☐	☐
2. Functional "x-ray on" indicator	☐	☐	☐
3. Functional Interlock device(s)	☐	☐	☐
4. Functional current (mA) and voltage (kVp) indicators	☐	☐	☐
5. Functional emergency shut-off button	☐	☐	☐
6. Labeling on the device (Caution: X-rays Produced When Energized)	☐	☐	☐
7. Only authorized personnel using the x-ray machine	☐	☐	☐
8. Proper documentation of x-ray safety training	☐	☐	☐
9. Availability of the X-Ray Safety Journal	☐	☐	☐
10. Availability of the manufacturer's operating manual	☐	☐	☐
11. Utilization log maintained	☐	☐	☐
12. Radiation safety survey performed following modifications	☐	☐	☐
13. Caution X-Ray postings	☐	☐	☐
14. Notice to Employees posting	☐	☐	☐
15. Radiation Producing Machine Permit or Timely Renewal posting	☐	☐	☐
16. **Radiation exposure within acceptable limits**	☐	☐	☐

COMMENTS:

Please take immediate action to remedy any problems found during this survey. If there are any changes to your machine inventory, it is the PI's responsibility to inform UCLA Radiation Safety within 10 business days of installation/disposal/modification of any machine. Failure to do so will result in a violation of California Department of Public Health regulations and may result in a fine or a lock out of instrumentation.

Revised: August 2011

For RSD Use Only ____________ HP Signature

1. Functionality of device indicators, interlocks, and emergency shut-off buttons
2. Device labeling
3. Authorized personnel working with radiation-producing equipment
4. Proper documentation of radiation safety training
5. Proper utilization of dosimetry, if issued
6. Security of radiation-producing machines
7. Authorized rooms used for radiation work
8. Current permit posting and/or "Timely Renewal Letter" posted
9. Availability of the Radiation Safety Manual
10. Availability of the manufacturer's operating manual
11. Maintenance of machine utilization log
12. Posting of Notice to Employees and "Caution – X-Ray"
13. Radiation exposure within acceptable limits
14. Adherence to UCLA Policy 905, including the proper utilization of personal protective equipment
15. Availability of Laboratory Hazardous Assessment Tool

RADIATION SAFETY KNOWLEDGE EVALUATIONS

In addition to the above audit checks, there may be performance evaluations based on the following topics:

1. Knowledge of radiation use in laboratory
2. Isotope(s) characteristics and associated hazards
3. Radiation safety policies and documentation requirements
4. Use of survey instrumentation
5. Laboratory security measures
6. Contamination control and decontamination
7. Radioactive waste management and disposal
8. Emergency procedures

FOLLOW UP AUDITS

If a deficiency is found during a radiation safety inspection, there will be a re-inspection audit to ensure safe working conditions. "Serious" findings (e.g., radioactive contamination, violation of the food and drink or personal protective equipment policy) must be corrected within 48 hours. EH&S will follow up on record-keeping findings within 90 days and all other findings within 30 days. Failure to correct deficiencies may lead to escalation of the issue to the Radiation Safety Officer, Director of EH&S, Department Chair, Assistant Dean, Dean, and the Office of the Vice Chancellor of Research.

In addition, a failed re-inspection audit may result in the issuance of a Strike Memorandum based on the EH&S Radiation Safety Office Three Strike Policy (Appendix D).

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Chapter 13: Emergency Response

Medical Emergencies

In the event that a radiological incident involves a serious or life-threatening injury, call 911 immediately. Dialing **911 from a campus phone** (**310-825-1491** from a cell phone) will connect the caller with the UCLA police department who will subsequently arrange immediate medical assistance as necessary and contact EH&S. Administer first aid as necessary; medical care should always be the first priority. To minimize radiation exposure, the principles of time, distance and shielding should be followed by all caregivers.

Radioactive Material Spill Response

MAJOR SPILLS

The most common type of radiological incident involves the spill of a radioactive material solution to areas outside of the immediate laboratory work space. Spills are divided into two categories: major and minor. A spill is defined as major if: greater than 100 microcuries of beta, gamma, or x-ray emitting radioactive material is spilled; any quantity of alpha emitting radioactive material is spilled; the radioactive material becomes airborne; radioactive material is spilled in (or radioactive contamination spreads to) areas outside of approved radioactive material use locations; there is any radioactive contamination on the skin of an individual; or any radioactive material has been inhaled or ingested. In the event of a major spill, the following actions should be taken by laboratory personnel:

1. Stop the spill from spreading and cover with absorbent material, but do not attempt to clean it up.
2. Notify all persons not involved with the spill to vacate the laboratory.
3. Shield the spill using lead (x-ray and gamma ray emitters) and/or Plexiglas™ (alpha and beta emitters) only if it can be done without further spreading contamination or significantly increasing personal radiation exposure.
4. Isolate the spill area. If possible, close and lock doors to the room; if the radioactive contamination has spread to areas outside of an approved radioactive material-use location, set up physical boundaries to prevent access to the contaminated area.
5. Evacuate the room and place radioactive material warning signs on all entrances to the spill location.
6. Make sure that all those directly involved with the spill do not leave the area; using an appropriate radiation detection instrument (e.g., Geiger-Mueller counter, sodium iodide detector, or liquid scintillation counter), survey for personal contamination.
7. Remove all contaminated articles of clothing (e.g., lab coat, shoes) and place in thick (3 mil or greater) plastic bags.
8. Immediately call the EH&S Hotline at (310) 825-9797.

VOLATILIZATION AND AIRBORNE RADIOACTIVE MATERIAL

Work with any volatile radioactive material must be specifically approved by EH&S and performed in a certified fume hood or biosafety cabinet. If radioactive material unintentionally volatilizes during an experiment, or if solid radioactive material suddenly becomes airborne:

1. Temporarily hold your breath.
2. Cover the radioactive material, if possible.
3. Adjust the fume hood sash to maximize the inward airflow; if working on a bench top, turn off the ventilation to the room so as to prevent the spread of radioactive material to other locations in the building.
4. Evacuate the room, locking all doors on the way out.
5. If the laboratory environment is not maintained under a negative pressure, seal the room using tape and plastic sheeting.
6. Immediately call the EH&S Hotline at (310) 825-9797.

PERSONAL CONTAMINATION

UCLA Policy 905 (see Appendix D) mandates that all individuals working with radioactive material must wear long pants (or equivalent), closed-toed shoes, an appropriate lab coat, protective eye-wear, and disposable gloves. Should an area of skin become contaminated while working with radioactive material, it is important to begin decontamination efforts immediately. Radioactive material that is deposited over a small area of skin may lead to highly localized radiation doses to the skin and nearby organs.

To remove skin contamination, wash the contaminated area with mild soap and tepid water; pay special attention to skin folds, areas between fingers, and around fingernails. Repeat this washing as necessary. Stop decontamination efforts if the skin begins to redden or become irritated. Vigorous cleaning may abrade the skin and lead to absorption of the radioactive material into the body.

If it is suspected that radioactive material has entered the body through inhalation, ingestion, absorption, or injection, immediately call the **EH&S Hotline at (310) 825-9797**. If possible, determine the radioisotope, chemical form, and quantity involved.

CLEAN UP OF MINOR SPILLS

Only appropriately trained laboratory personnel should clean up a radioactive materials spill. In the event of a minor spill, the following actions should be taken by laboratory personnel:

1. Stop the spill from spreading using absorbent materials (e.g. disposable blue chux, paper towels).
2. Notify all persons in the laboratory that a spill has occurred.
3. Isolate the spill area; establish a perimeter around the spill site using an appropriate radiation detection instrument. Set up physical boundaries and label the area with radioactive material warning signs.

4. Before beginning decontamination procedures, wear appropriate personal protective equipment (e.g., laboratory coat, protective eye-wear, booties, two sets of gloves) and personal dosimeters, if previously issued by EH&S.

5. Using a common household cleaner (e.g., Formula 409®, Simple Green®), dampen a paper towel and begin scrubbing from the outermost edges of the spill toward the center. Never spray cleaner directly on the spill area, as this may spread the contamination. Clean small areas at a time.

6. Frequently check the progress of decontamination efforts using an appropriate radiation detection instrument.

7. Dispose of all contaminated cleaning items (e.g., paper towels, gloves) in double, clear plastic bags; complete and attach a radioactive waste tag to the bag. Refer to Chapter 8: *Radioactive Waste* for additional information.

8. Perform a final direct meter survey and wipe test of the spill area to ensure that there is no residual radioactive contamination above background levels. If levels of radioactive contamination persist above the limits noted in Chapter 7: *Radiation Surveys*, immediately call the ***EH&S Hotline at (310) 825-9797***.

9. Document the incident and final survey results.

Other Radioactive Material Incidents

ON-CAMPUS INCIDENTS

Certain radioactive material incidents require timely reporting to the California Department of Public Health (CDPH) – Radiologic Health Branch and as such, EH&S should be contacted as soon as possible after discovering any of the following:

- Missing radioactive material, including waste items
- Unmonitored release of radioactive material to the environment (spill), including any airborne and/or sanitary sewer system releases
- Any personal radioactive material contamination, whether external or internal

RADIOLOGICAL EMERGENCIES

UCLA has an emergency response plan in the event of a widespread radiological emergency that affects the Los Angeles area. Trained emergency personnel, including radiation safety specialists, will be notified when their response is required in these cases.

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Appendix A: Theory of Ionizing Radiation

Effects of Ionizing Radiation

The basic principle of radiation protection is based on the belief that any radiation exposure can cause detrimental health effects and is a consequence of the energy transfer due to ionization and excitation of the body's cells. The type of radiation damage may be broadly classified into two categories: Deterministic (nonstochastic) and stochastic. Deterministic effects, or "early" effects, occur immediately after a certain threshold dose reached, the severity of which will increase with dose. Stochastic effects ("late" effects) on the other hand, occur randomly; the probability of their occurrence rather than severity of the effect depends on the size of the dose.

The biological damage caused by ionizing radiation can be either directly through DNA strand breaks, or indirectly through the formation of free radicals within the cell. Furthermore, the biological harm to tissue depends not only on the dose received but also on the radiation type and energy. For the same dose, alpha or neutron radiation will cause greater harm compared to gamma radiation because the ionization events produced by alpha or neutron radiation will be much more closely spaced reducing the chance of repair by the cells.

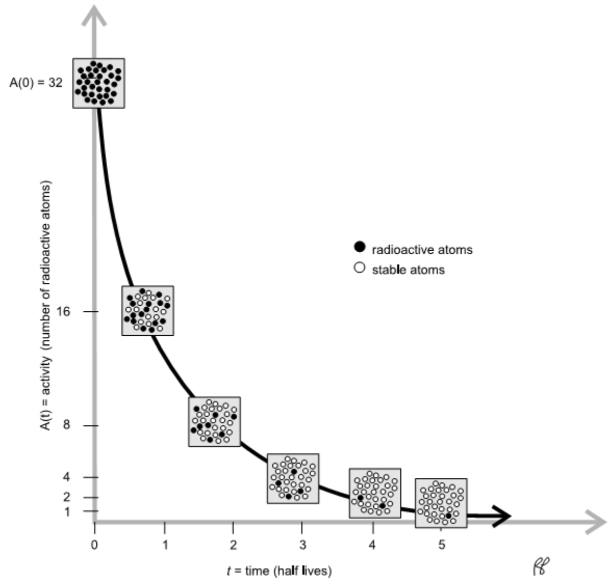
Basic Radiation Theory

An unstable nucleus will spontaneously rearrange itself until it is stable either by ejecting portions of its nucleus, or by emitting excess energy in the form of photons.

HALF-LIFE (T)

The time required for a given number of radioactive atoms of a specific radionuclide to decay to half its original quantity is known as the half-life. After another half-life, half of the remaining atoms will have decayed as well. This process continues until the number of atoms eventually comes close to zero. For example, hydrogen-3 (tritium) has a half-life of 12.3 years. Thus, if we have a million atoms of H-3 today, 500 thousand atoms will decay in 12.3 years. After an additional 12.3 years, only 250 thousand atoms, or one quarter of the original atoms will remain. This property is unique to each radioactive isotope and cannot be altered. See Figure A.1.

Figure A.1 – Decay Curve



Many isotopes commonly used in research have relatively short half-lives. Short-lived isotopes should be used when feasible to reduce radiation exposures and radioactive waste generation. It may be necessary to account for radioactive decay when preparing for experimental, medical, and teaching procedures as well as when procuring isotopes and managing radioactive waste. The activity of a radioactive sample needs to be known to ensure that a correct medical dose will be administered, an experimental procedure will be successful, a measurement will be properly interpreted, and that regulatory limits will not be exceeded.

The simple mathematical description of exponential radioactive decay can be described by:

$A = A_0 e^{-\lambda t}$ (or) $A = A_0\ 0.5^{(n)}$

Where:

- A = Activity remaining after a time interval (t)
- A_0 = Original activity of the sample at (t_0), in Ci, Bq, or dpm
- t = Elapsed time for decay
- λ = Decay constant and defined as ln 2/T, or 0.693/T
- T = Half-life
- n = Number of elapsed half-lives (t/T)

Example: What is the remaining activity fifteen days after the time when a sample was known to contain 75 mCi of I-131? The physical half-life of I-131 is 8.04 d (Table A.2).

T = 8.04 d for I-131, therefore n = t/T = 15/8.04 = 1.87

$A = A_0 e^{-\lambda t}$ (or) $A = A_0\ 0.5^{(n)}$

$A = 75\ \text{mCi} * e^{-((\ln 2/8.04\ d)*(15\ d))} = 20.6\ \text{mCi}$ (or) $A = 75\ \text{mCi} * 0.5^{(1.87)} = 20.6\ \text{mCi}$

ACTIVITY

The quantity of a radioactive source is expressed as the number of decay events occurring per unit time. The basic unit of measure used here in the United States is the Curie (Ci). The Systéme International (SI) uses the Bequerel (Bq) as the unit of activity. One Ci is equal to 37 billion (3.7×10^{10}) decays per second (dps) while one Bq is equal to one decay per second. In many cases, the standard multiple of these units are either too high or too low for everyday use and will often be expressed in mCi/µCi and MBq, respectively.

1 Ci = 3.7×10^{10} dps = 3.7×10^{10} Bq

1 Bq = 1 dps = 27×10^{-12} Ci

Activity may be calculated as follows:

$$A = \lambda N$$

Where:

A = Activity
λ = Decay constant defined as ln2/T or 0.693/T
T = half-life
N = Number of atoms

Types of Radioactive Decay

Radioactive nuclides can be grouped into four major categories that will determine how they will undergo transformation to become stable:

- Heavy nuclei with Z > 83
- Neutron-rich nuclei
- Proton-rich nuclei
- Excited nuclei with excess energy

Transformation of Heavy Nuclei: ALPHA DECAY

Alpha emission will occur in very large unstable atoms with high atomic numbers (Z >83). The unstable nucleus will fragment ejecting an alpha particle consisting of two neutrons and two protons, essentially the nucleus of a helium ion.

Due to its massive size, +2 charge, and low velocity, alpha particles lose energy very quickly through ionization and excitation interactions in matter. As a result, alpha particles are extremely limited in their ability to penetrate matter, and exposure would not pose a radiation hazard since a thin sheet of paper or the dead outer layer of human skin is sufficiently thick to absorb all alpha radiation. If ingested, however, alpha particles can deliver a very large radiation dose to internal tissue.

Transformation of Heavy Nuclei: NEUTRON DECAY (FISSION)

Similarly to alpha decay in a process called nuclear fission, the nucleus of unstable atoms with very high atomic mass may occasionally break into fragments. For example, Californium-252 (Cf-252) will undergo (1) decay by fission for every (31) decays by alpha emission. Nuclear transformation by fission will almost always be accompanied by the emission of neutrons.

The energy spectrum of the neutrons emitted is complex. Depending on their source, neutron energy can range from 0.015 eV to tens of MeV. As neutrons do not carry a charge, they travel through a medium without interaction until it collides with an atomic nucleus of the absorber nuclei. The collision is governed by the laws of conservation of momentum and energy and is called elastic. Maximum energy transfer occurs when neutrons collide with hydrogen nuclei (essentially a proton). For atoms heavier than hydrogen, the maximum energy that can be transferred decreases as the atomic mass increases. Hence, hydrogenous materials such as water tanks are typically used as neutron shields.

Transformation of Neutron-Rich Nuclei: BETA DECAY

Beta emission occurs when nuclei with excess neutrons achieve stability by a process in which a neutron is converted into a proton under emission of a beta particle and an antineutrino. This beta particle is essentially a high-speed electron. Beta particles are emitted with a continuous energy distribution ranging from zero to the maximum energy determined by mass-energy considerations for a particular nuclear transformation. The energy difference between this maximum and the actual energy of the beta particle is carried off by the charge-less and nearly mass-less antineutrino.

Energies of beta particles are often expressed in terms of both average energy and maximum energy. As a general rule of thumb, the average beta energy is approximately one third of the maximum energy. However, unless specified otherwise, the energy of a beta emitter given in literature is the maximum energy.

The maximum range of a beta particle can be determined by the following equations:

$R = 0.407E^{1.38}$ $\quad\quad E_{max} \leq 0.8$ MeV
$R = 0.542E - 0.133$ $\quad\quad E_{max} \geq 0.8$ MeV

Where:

R = Range in g/cm^2
E = Maximum energy in MeV

Specific information for common beta-emitting radioisotopes used in academia are referenced in table A.1.

Table A.1 – Common Beta-Emitting Radioisotopes[a]

Parameter	H-3	C-14	S-35	P-33	P-32
Half Life	12.28y	5730y	87.4d	25.4d	14.29d
Max Energy (MeV)	0.019	0.156	0.167	0.249	1.71
Average Energy (MeV)	0.006	0.049	0.049	0.077	0.695
Range in Air (cm)	0.5	23	26	49	610
Range in H_2O (cm)	<0.0001	0.029	0.04	0.06	0.8
Fraction through skin[b]	negligible	0.11	0.16	0.37	0.95
Dose Rate, mrad/h[c]	negligible	1.1	1.2	4.0	9.2

a. Shapiro (1990)
b. Fraction through the "standard" dead layer of skin, 7 mg/cm^2.
c. Dose rate to basal cells of epidermis from 1 nCi/cm^2 deposited on skin surface.

Transformation of Proton-Rich Nuclei: POSITRON DECAY

Positron emission occurs when unstable, proton-rich nuclei reach stability by converting a proton into a neutron under emission of a positron and neutrino. A positron, or beta plus particle, can be described as a positively charged electron.

The positron, unlike beta particles, survives only briefly. Annihilation radiation will always accompany positron emission as positrons are antimatter and will interact and be annihilated by electrons so plentiful in matter. The annihilation of the positron and electron will result in the simultaneous emission of two 0.511 MeV gamma photons, 180 degrees from each other.

From a radiation protection standpoint, positron emission should always be associated with gamma radiation for all exposure controls involving shielding and dosimetry.

Stabilization of Excited Nuclei: GAMMA EMISSION

If a nuclei contains a stable amount of nucleons and neutron-to-proton ratio but the energy of the nucleus is greater than its resting level, the nuclei is said to be in a metastable state. Gamma ray emission provides a mechanism for ridding metastable nuclei of their excitation energy without affecting the atomic number or atomic mass number of the atom.

A gamma ray is an uncharged packet of energy, or a photon. As it belongs to the electromagnetic spectrum, gamma rays have no mass and travel at the speed of light. It cannot be distinguished from photons of the same energy from different sources, such as x-rays.

Gamma rays will only lose energy through chance encounter with nuclei in matter, resulting in the ionization of energetic electrons. If only a portion of the energy is removed, the remainder will continue to travel, with the speed of light, as a lower energy photon. Accordingly, there is a finite probability that any single gamma photon can travel through a medium without interaction. This probability depends on the density and thickness of the medium, as well as the energy of the gamma ray. In terms of the efficiency of an absorbing medium for photons, the terms “half-value layer” (HVL) or “tenth-value layer” (TVL) are applied. The HVL or TVL describes the thickness in which 50 or 90 percent, respectively, of incident photons will be attenuated by a specified medium.

Specific information for common gamma-emitting radioisotopes used in academia are referenced in table A.2.

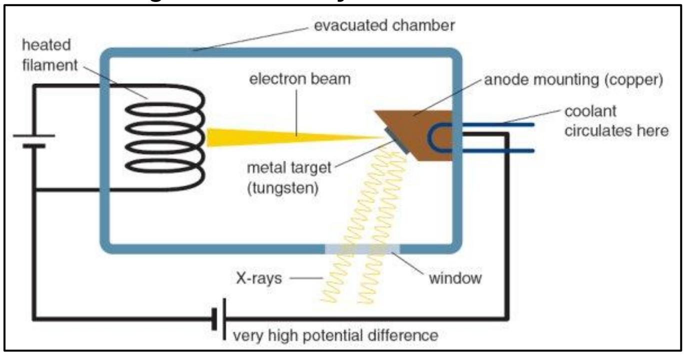
Table A.2 – Common Gamma Emitting Radioisotopes

NUCLIDE	Γ[a]	*T* Physical Half-Life	Shielding Factors I/I_0 in cm Lead		NUCLIDE	Γ[a]	*T* Physical Half-Life	Shielding Factors I/I_0 in cm Lead	
			0.5 (HVL)	0.1 (TVL)				0.5 (HVL)	0.1 (TVL)
Barium-133	2.4	10.4 years	0.1	0.5	Molybdenum-99	1.8	66.7 hours	0.77	2.55
Beryllium-7	0.3	53.3 days	0.5	1.5	Oxygen -15	5.9	122.2 sec.	0.55	1.6
Carbon-11	5.9	20.3 min.	0.55	1.6	Palladium-103	0.86	16.97 days	0.0008	0.003
Cesium-137	3.3	30.0 years	0.8	2.4	Potassium-42	1.4	12.4 hours	1.7	5.2
Chromium-51	0.16	27.7 days	0.2	0.7	Potassium-43	5.6	22.4 hours	0.5	1.8
Cobalt-57	0.9	270 days	0.01	0.05	Radium-226	8.25	1600 years	1.4	4.6
Cobalt-60	13.2	5.26 years	1.5	4.50	Rubidium-86	0.5	18.6 days	1.4	4.1
Fluorine-18	5.7	109.7 min	0.55	1.6	Scandium-47	0.56	3.40 days	0.05	0.17
Gallium-67	1.1	78.8 hours	0.1	0.5	Selenium-75	2.0	120 days	0.1	0.5
Gold-198	2.3	2.69 days	0.33	1.1	Sodium-22	12.0	2.60 years	0.9	3.6
Indium-111	3.24	2.81 days	.023	0.2	Sodium-24	18.4	15.0 hours	1.8	5.7
Indium-113m	1.77	99.4 min.	0.2	0.9	Strontium-85	3.0	65.1 days	0.1	1.1
Iodine-123	0.67	13 hours	0.04	0.2	Tantalum-182	6.8	115.0 days	1.2	4.0
Iodine-125	2.7	60.2 days	0.002	0.006	Technetium-99m	0.7	6.30 hours	0.02	0.08
Iodine-131	2.2	8.04 days	0.3	1.1	Tin-113	1.7	115 days	0.001	0.004
Iridium-192	4.8	74.2 days	0.3	2.0	Thallium-201	0.447	73.1 hours	0.03	0.1
Iron-59	6.4	45 days	1.5	4.5	Xenon-133	0.14	5.31 days	0.003	0.015
Manganese-54	4.7	312 days	1.1	3.2	Zinc-65	2.7	245 days	1.4	4.1

X-Radiation Production

X-radiation (x-ray) production typically involves the use of electric potential to accelerate electrons towards a target material.

Figure A.2 – X-ray Tube Schematic

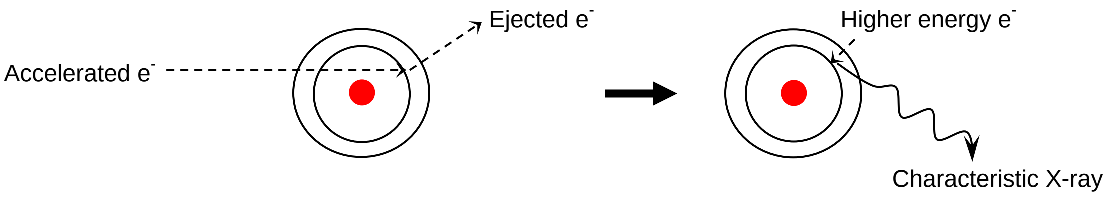


These accelerated electrons generate x-rays through two atomic processes: x-ray fluorescence and Bremsstrahlung.

X-ray Fluorescence

The bombarding electrons can eject electrons from the inner shells of the atoms of the target. Those vacancies will be quickly filled by electrons dropping down from higher levels, emitting characteristic x-rays with sharply defined frequencies associated with the difference between the atomic energy levels of the target atoms. Characteristic x-rays are used for the investigation of crystal structure by x-ray diffraction. Crystal lattice dimensions may be determined with the use of Bragg's law in a Bragg spectrometer. As seen in Figure A.3 below, the accelerated electron ejects an orbital electron from the target atom’s inner shell and another electron from a higher energy level within the atom fills the vacancy and x-rays.

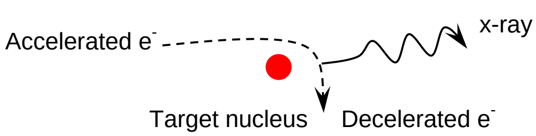
Figure A.3: X-ray Fluorescence



Bremsstrahlung

Literally translating to “braking radiation”, Bremsstrahlung refers to the deceleration of electrons (beta particles) through interaction with the target nucleus (Figure A.4). Through conservation of energy, the energy lost as the electron loses kinetic energy is emitted in the form of x-rays. Bremsstrahlung is characterized by a continuous distribution of x-rays which become more intense and shifts toward higher frequencies when the energy of the bombarding electrons is increased. The rate at which Bremsstrahlung radiation is generated depends on the atomic number of the target material. Higher atomic number targets cause the electron to decelerate at a greater rate; thus, the energy of the x-rays produced is greater.

Figure A.4: Bremsstrahlung radiation



The maximum energy of the x-ray produced corresponds to the voltage applied to the circuit i.e. 50 kV applied to the tube can generate x-rays up to 50 keV. Most of the kinetic energy of the electron striking the target is actually converted to heat with less than one percent being transformed into x-rays. X-ray tubes are designed to dissipate this heat through various mechanisms, e.g., liquid cooling, rotating target assembly, metal lubricant, etc.

Appendix B: Acronyms and Abbreviations

ALARA	As Low As Reasonably Achievable
ALI	Annual Limit on Intake
ANSI	American National Standards Institute
ARC	Animal Research Committee
Bq	Becquerel
C	Coulomb
CCR	California Code of Regulations
CDE	Committed Dose Equivalent
CDPH	California Department of Public Health
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
Ci	Curie
cpm	Counts per Minute
CT	Computed Tomography
DAC	Derived Air Concentration
DDE	Deep Dose Equivalent
DOT	Department of Transportation
dpm	Disintegrations per Minute
dps	Disintegrations per Second
EDE	Effective Dose Equivalent
EH&S	Office of Environment, Health & Safety
EPA	Environmental Protection Agency
eV	Electron Volt
GM	Geiger-Mueller Counter
Gy	Gray
HP	Health Physicist
HVL	Half Value Layer
ICRP	International Commission on Radiological Protection
LDE	Lens Dose Equivalent
LHAT	Laboratory Hazard Assessment Tool
LSC	Liquid Scintillation Counter
LSV	Liquid Scintillation Vial
NCRP	National Council of Radiation Protection and Measurements
NORM	Naturally Occurring Radioactive Material
NRC	Nuclear Regulatory Commission
NRWQ	New Radiation Worker Qualification
NVLAP	National Voluntary Laboratory Accreditation Program
OARO	Office of Animal Research Oversight
OHF	Occupational Health Facility
ORSC	Office of the Radiation Safety Committees
OSL	Optically Stimulated Luminescence
PET	Positron Emission Tomography
PI	Principal Investigator
PPE	Personal Protective Equipment
QF	Quality Factor

R	Roentgen
RAM	Radioactive Material
rem	Roentgen-Equivalent Man
RIA	Radioimmunoassay
RMP	Radioactive Materials Permit
RPMP	Radiation-Producing Machines Permit
RSC	Radiation Safety Committee
RSJ	Radiation Safety Journal
RSM	Radiation Safety Manual
RSO	Radiation Safety Officer
RSP	Radiation Safety Program
RSS	Radiation Safety Supervisor
RURE	Report of Unusual Radiation Exposure
SDE	Shallow Dose Equivalent
SI	Safety Index
SOP	Standard Operating Procedure
Sv	Sievert
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent Dosimeter

Appendix C: Definitions

Absorbed Dose – The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

Activity – The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the Becquerel (Bq).

Agreement State – Any state with which the Nuclear Regulatory Commission has entered into an effective agreement under section 274b of the Atomic Energy Act of 1954, as amended. California is an agreement state and as such, regulates the use of radioactive material within its boundaries.

ALARA – Acronym for “As Low As Reasonably Achievable” Making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Alpha Particle – A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air).

Annual Limit on Intake (ALI) – The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rem (0.5 Sv) to any individual organ or tissue.

Background Radiation – Radiation from cosmic sources; naturally occurring radioactive material, including radon and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents.

Becquerel (Bq) – The international unit of activity, having the value of one disintegration per second.

Beta Particle – A charged particle that is emitted from the nucleus of a radioactive element during radioactive decay of an unstable atom. A negatively charged beta particle is identical to an electron, while a positively charged beta particle is called a positron.

Bioassay – The determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

Bremsstrahlung – The electromagnetic radiation produced when charged particles decelerate or change direction through electrostatic interaction with matter.

Committed Dose Equivalent – The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent – The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Computed Tomography – A radiographic technique that produces a detailed image of tissue by using a narrowly collimated beam of x-rays that rotates in a full arc around the patient. An array of detectors, positioned at several angles, records those x-rays that pass through the body. The image is created by a computer that uses multiple attenuation readings taken around the periphery of the body part. The computer calculates tissue absorption and produces a representation of the tissues that demonstrates the densities of the various structures.

Contamination, Radioactive – Undesirable radioactive material that is either airborne or deposited in (or on the surface of) structures, objects, soil, water, or living organisms.

Controlled Area – An area, outside of a restricted area but inside the site boundary, access to which can be limited by the Principal Investigator or licensee for any reason.

Coulomb (C) – A unit of electrical charge equal to the quantity of charge transferred in one second by a steady current of one ampere.

Curie (Ci) – A unit of activity having the value 3.7×10^{10} disintegrations per second.

Decay,Radioactive – The disintegration of the nucleus of an unstable atom by spontaneous emission of energy in the form of high speed particles or electromagnetic waves.

Declared Pregnant Woman – A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

Deep-Dose Equivalent – *A term that applies to external whole-body exposure and is t*he dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

Derived Air Concentration – The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI.

Disintegration – See Decay, Radioactive.

Dose – A generic term that relates biological risk to a radiation exposure; may refer to any of the following: absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent.

Dose Equivalent – The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dosimeter – A portable instrument used to measure the total accumulated exposure to ionizing radiation.

Effective Dose Equivalent – The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

Electron Volt (eV) – A unit of energy equal to the amount of kinetic energy gained by a single unbound electron when it accelerates through an electric potential difference of one volt.

Exposure – 1. A measure of the ionization in air caused by x-ray or gamma radiation. The unit of exposure is the roentgen (R). 2. A term meaning exposure to radiation or radioactive material.

External Dose – That portion of the dose equivalent received from radiation sources outside the body.

Extremities – The hands, forearms, elbows, feet, knees, and legs below the knees.

Gamma Ray – High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an atom.

Geiger-Mueller Counter – An instrument that measures radiation as it passes through a gas-filled tube, causing the ionization of gas molecules and producing an electrical discharge. It is sensitive to beta particles, but relatively insensitive to gamma rays and x-rays. The response is not energy dependent.

Gray (Gy) – The international unit of absorbed dose, having the value of 1 Joule/kilogram (100 rad).

Half-Life, Biological – The time required for a biological system to eliminate, by natural processes, half of the amount of a substance that has entered it.

Half-Life, Effective – The time required for the activity of a particular radioisotope deposited in a living organism to be reduced by 50 percent as a result of the combined action of radioactive decay and biological elimination.

Half-life, Radioactive – The time required for half the atoms of a particular radioisotope to decay into another isotope.

Half Value Layer – The thickness of any given absorber that will reduce the intensity of an original beam of ionizing radiation to one-half of its initial value.

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

Internal Dose – That portion of the dose equivalent received from radioactive material taken into the body.

Lens Dose Equivalent – *A term that* applies to the external exposure of the lens of the eye and is the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

Liquid Scintillation Counter – An instrument that quantifies the amount of radioactivity in a sample by measuring the light produced from the chemical scintillation of a solvent.

Naturally Occurring Radioactive Material – Radioactive material found in the environment, (such as uranium, thorium and potassium) and any of their decay products (such as radium and radon).

Nonstochastic Effects – Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect (also called a deterministic effect).

New Radiation Worker Qualification (NRWQ) – Initial radiation safety training provided by the Radiation Safety Program that includes such topics as basic radiation safety principles, radiation exposure risk, safe handling of radioactive material, radiation detection instruments, radioactive waste handling, and university-specific policies. Successful completion of the NRWQ is required prior to working with radioactive material at UCLA.

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

Optically Stimulated Luminescence – A method for measuring radiation dose where a crystalline material (such as aluminum oxide) is used to absorb ionizing radiation and a laser is used to release the stored energy.

Personal Protective Equipment – Protective equipment worn by laboratory workers to minimize exposure to hazards when engineering and administrative controls are not feasible or effective. In radiation safety, such items include protective clothing, closed-toed shoes, laboratory coats, disposable gloves, eye protection, respirators, and lead aprons.

Pig – A container (usually lead or depleted uranium) used to ship or store radioactive materials. The thick walls of this shielding device protect the person handling the container from radiation. Large containers used for spent fuel storage are commonly called casks.

Positron Emission Tomography – An imaging modality that detects, through coincidence counting, 511 keV gamma radiation events and produces tomographic images that reflect the distribution of a positron emitting radiopharmaceutical in the body or individual organs.

Principal Investigator – The lead investigator identified on a radioactive material use permit and/or radiation-producing machine permit.

Quality Factor – A modifying factor that is used to derive dose equivalent from absorbed dose.

Rad – A unit of absorbed dose having the value of 0.01 joule/kilogram (0.01 gray).

Radiation, Ionizing – Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, protons, or other particles capable of producing ions, Excludes non-ionizing radiation such as sound or radio waves, or visible, infrared, or ultraviolet light.

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

Radiation-Producing 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 – A regulatory mandated committee responsible for the development and oversight of radiation safety policies at UCLA.

Radiation Safety Officer – The individual responsible for implementing the policies of the Radiation Safety Committee and manager of the Radiation Safety Program.

Radiation Safety Program – A program under the Research Safety Division of the Office of Environment, Health & Safety that facilitates the safe use of radiation and radioactive material at UCLA.

Radiation Safety Supervisor – When designated by the Principal Investigator, the individual responsible for all radiation safety related obligations within a laboratory group.

Radioactive Material – Any material which emits radiation spontaneously.

Radioactive Materials Permit – A document issued by the Radiation Safety Program that defines the limitations of the Principal Investigator regarding the use of radioactive materials. These limitations include authorized isotopes, possession limits, dosimetry requirements, chemical form restrictions, and special conditions.

Radiation-Producing Machines Permit – A document issued by the Radiation Safety Program that defines the limitations of the Principal Investigator regarding the use of radiation-producing machines. These limitations include authorized machines, dosimetry requirements, and special conditions.

Roentgen Equivalent Man (rem) – A unit of dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert).

Report of Unusual Radiation Exposure – A report issued by the Radiation Safety Program that informs a monitored individual that their radiation dose has exceeded the ALARA II level, but has not yet exceeded the occupational dose limit.

Restricted Area – An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Roentgen (R) – A unit of exposure to ionizing radiation. It is the amount of gamma or x-rays required to produce ions resulting in a charge of 0.000258 coulombs/kilogram of air under standard conditions.

Safety Index – A number assigned by the Radiation Safety Program to each Radioactive Material Permit based on the relative hazard of all types and quantities of radioactive material approved for use.

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.

Shallow-Dose Equivalent – A term that applies to the external exposure of the skin of the whole body or the skin of an extremity and is the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2).

Sievert (Sv) – The international unit of dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rem).

Stochastic Effects – Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Survey – An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Tenth Value Layer – The thickness of any given absorber that will reduce the intensity of an original beam of ionizing radiation to one-tenth of its initial value.

Thermoluminescent Dosimeter – A small device used to measure radiation exposure by measuring the amount of visible light emitted from a crystal in the detector after exposure to ionizing radiation.

Total Effective Dose Equivalent – The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Total Organ Dose Equivalent – The sum of the deep dose equivalent (for external exposures) and committed dose equivalent (for internal exposures) for an organ or tissue.

Unrestricted Area – *A*n area, access to which is neither limited nor controlled by the licensee.

Very High Radiation Area – *A*n area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or 1 meter from any surface that the radiation penetrates.

Weighting Factor – For an organ or tissue, the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly.

Whole Body – The head, trunk, arms above the elbow, and legs above the knee.

X-Ray – Penetrating electromagnetic radiation having a wavelength that is much shorter than that of visible light. These rays are usually produced by excitation of the electron field around certain nuclei.

X-Ray Diffraction Safety Training – Initial radiation safety training provided by the Radiation Safety Program that includes topics such as x-ray diffraction unit characteristics, sources of radiation exposure, basic radiation safety principles, radiation exposure risk, and university-specific policies. Successful completion of the X-ray Diffraction Safety Training is required prior to operating an x-ray diffraction unit at UCLA.

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Appendix D: Policies

UCLA Policy 905: Research Laboratory Personal Safety and Protective Equipment

ISSUING OFFICER: Vice Chancellor for Research

RESPONSIBLE DEPARTMENT: Environment, Health & Safety

EFFECTIVE DATE: February 1, 2010

SUPERSEDES: New

I. REFERENCES

1. University of California Policy on Management of Health, Safety and the Environment (10/28/2005);
2. Guiding Principles to Implement the University of California Policy on Management of Health, Safety and the Environment (10/28/2005);
3. UCLA Policy 811, Environmental Health and Safety
4. Code of Federal Regulations, Title 29 CFR, Part 1910, Subpart 1
5. California Code of Regulations – Subchapter 7. General Industry Safety Orders – Group 16. Control of Hazardous Substances – Article 109. Hazardous Substances and Processes - §5194. Hazard Communication.

II. STATEMENT

The University of California is committed to providing a healthy and safe working environment for all members of the campus community. It is University policy to comply with all applicable health, safety and environmental protection laws, regulations and requirements. The Occupational Safety and Health Administration (OSHA) ensures workplace safety through the enforcement of established federal legislation, and the California Occupational Safety and Health Administration (CalOSHA) operates as the acting regulatory enforcement body under the direction of the OSHA act.

Title 29 of the Code of Federal Regulations, Part 1910, Subpart 1. *Personal Protective Equipment*, states that "protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact." Pursuant to this regulation, and in an effort to prevent workplace injuries and illnesses, UCLA has established this Policy regarding Personal Protective Equipment (PPE) requirements for all campus research laboratory faculty, staff and students.

III. RESPONSIBILITIES

Preventing workplace injuries and illnesses is the responsibility of every member of the campus community. Specific responsibilities are assigned to higher level members of the research and teaching community in order to implement and ensure compliance with this Policy by their subordinate staffs.

The Chancellor has overall responsibility for compliance with health and safety requirements at all facilities and programs under campus control.

The Vice Chancellor for Research is responsible for the implementation of this Policy in all applicable research and teaching laboratories within his or her jurisdiction.

The UCLA Laboratory Safety Committee (LSC) is responsible for promoting a safe working environment in all research and teaching laboratories on campus.

Department Chairpersons are responsible for communicating, promoting and enforcing the Policy in their respective research and teaching areas.

Principal Investigators and laboratory management staff are responsible for complying with this Policy and ensuring their staff receive appropriate training and comply with this Policy as it relates to their research and teaching activities.

All staff members working in laboratory areas are responsible for following laboratory safety requirements and for wearing PPE as outlined in this Policy and in laboratory-specific safety training.

The UCLA Office of Environment, Health & Safety (EH&S) is responsible for inspection of laboratories and enforcement of this Policy. In cases where laboratory activities pose an immediate danger to life or health, designated EH&S staff have the responsibility and authority to order the temporary cessation of the activity until the hazardous condition is abated.

IV. SAFETY REQUIREMENTS

The following requirements pertain to all research and teaching laboratory environments utilizing hazardous chemical, hazardous biological or unsealed radiological materials (see section V., below). The requirements do not apply to those research and teaching laboratories that involve solely mechanical, computer, laser, other non-ionizing radiation, or electrical operations; these hazards will be addressed under separate policies, as appropriate. In addition, these requirements will not apply to laboratories which have been designated as non-hazardous materials use areas. In order to qualify as a non-hazardous materials use area, a laboratory must obtain approval and appropriate labeling from EH&S. EH&S, in cooperation with regulation mandated safety committees, has the final authority for determining whether any specific material is classified as hazardous. Deviations from these requirements, including the defining of specific hazardous materials use areas within rooms, may be permitted under certain conditions and will require express, written approval from EH&S.

A. Full length pants, or equivalent, and close-toed shoes must be worn at all times by all individuals that are occupying the laboratory area. The area of skin between the shoe and ankle should not be exposed.

B. Protective gloves must be worn while utilizing any hazardous chemical, biological or unsealed radiological material. These gloves must be appropriate for the material being used. The Material Safety Data Sheet (MSDS) for the material should be referenced when determining the effectiveness of the type of glove to be used. Additionally, the EH&S website offers guidance on glove selection based on material handling as well as links to other resources. This requirement does not apply when working with non-hazardous materials and an open flame or other heat source that might cause injury by melting plastic gloves.

C. Laboratory coats, or equivalent, are required to be worn while working on, or adjacent to, all bench top procedures utilizing hazardous chemicals, biological or unsealed radiological materials. These laboratory coats must be appropriately sized for the individual and be buttoned to their full length. Laboratory coat sleeves must be of a sufficient length to prevent skin exposure while wearing gloves.

D. Flame resistant laboratory coats must be worn when working with pyrophoric materials or large amounts (greater than four (4) liters) of flammable liquids. It is recommended that cotton (or other non-synthetic material) clothing be worn during these procedures to minimize injury in the case of a fire emergency.

E. Laboratory coats may not be worn outside of a laboratory unless the individual is traveling directly to an adjacent laboratory work area. Protective gloves must not be worn in any public area outside of the laboratory (i.e., hallways, elevators, offices). Gloves should also be removed prior to handling any equipment that could likely result in cross-contamination (e.g., telephones, computer work stations, etc.).

F. Each department or research unit shall be responsible for providing professional laundry services as needed to maintain the hygiene of laboratory coats. They may not be cleaned by staff members at private residences or public laundry facilities. Any clothing that becomes contaminated with hazardous materials must be decontaminated before it leaves the laboratory.

G. Eye protection or equivalent engineering controls must be used while handling any hazardous chemical, biological or unsealed radiological materials. All eye protection equipment must be American National Standards Institute (ANSI) approved and appropriate for the work being done.

H. Some operations and procedures may warrant further PPE, as indicated by the MSDS, the standard operating procedures for the material being used, facility policies, regulatory requirements, or the EH&S Laboratory Hazard Assessment Tool.

V. DEFINITIONS OF HAZARDOUS MATERIALS

The following materials are defined as hazardous for the purposes of this Policy:

1. Any unsealed radioactive material.

2. Biological materials in the BSL-2 Category, or greater.

3. Chemicals listed as Select Carcinogens and Regulated Carcinogens. (See *http://www.dir.ca.gov/Title8/5191.html* for the Cal/OSHA criteria for select carcinogens)

4. Chemicals listed as Reproductive Toxins. (See *http://www.oehha.org/prop65/prop65_list/Newlist.html#files* for a list of reproductive toxins and carcinogens identified under California Proposition 65)

5. Chemicals listed as Toxic or Highly Toxic. (See *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10100* for OSHA guidance on identifying Highly Toxic Chemicals)

6. Flammable chemicals in excess of one (1) liter by volume, or any amount of violently air reactive or water reactive chemicals.

7. Corrosive chemicals in concentrations of one (1) molar or greater.

8. Known significant skin or eye irritants.

This list is to be used as a guideline and allows for some laboratories to be classified as non-hazardous materials laboratories. It does not supersede Cal/OSHA regulations or accepted safe work practices for specific materials. PPE and other safety measures, as appropriate, must be used to protect workers from any and all known hazards that are present in all work-related activities at UCLA. Refer to the California Code of Regulations for additional guidance in developing protective measures for laboratory use of hazardous materials.

ISSUING OFFICER

/s/ Roberto Peccei

Vice Chancellor - Research

Questions concerning this policy or procedure should be referred to the Responsible Department listed at the top of this document.

UCLA Radiation Safety Program: Radioactive Material Use Laboratory Food & Drink Policy

UCLA ENVIRONMENT, HEALTH & SAFETY	**Research Safety Division** Radiation Safety Program Radioactive Material Use Laboratory Food & Drink Policy Memorandum
	501 Westwood Plaza, 4th Floor • Los Angeles, CA 90095 Phone: 310-825-5689 • Fax: 310-825-7076 • www.ehs.ucla.edu

The California Code of Regulations, Title 8, Section 3368 addresses the consumption of food and beverages in locations such as cafeterias and break rooms, as well as areas where these items may become contaminated by toxic material. As the ingestion of radioactive material and their carrier compounds may cause adverse health effects, they are considered to be toxic substances by the RSP. This policy has been instated to prevent accidental intake of these materials.

The Radiation Safety Program does not allow consumption or storage of food or beverages in laboratories where open radioactive material is used or stored. The presence of food, food wrappers, coffee cups, drinking glasses, soda cans, water bottles, wine bottles or other similar items in designated radioactive material use areas will be considered as evidence that food or beverages are likely to have been, or will be, consumed in these locations. Laboratories that use sealed sources or radiation producing machines exclusively are exempted from this food and drink policy.

The following requirements will be adhered to by PIs and their staff regarding food and drink consumption and storage in designated radioactive material use areas:

1. A food and drink area may not be designated in a commissioned radioactive material use laboratory; and,
2. A food and drink area must be segregated from the radioactive work area via physical barriers such as walls and doors (i.e. a hallway outside of the laboratory room or an office with a securable door); and,
3. Food and drink, even when sealed, may not be placed or stored in a commissioned radioactive material use laboratory; and,
4. Unopened food and drink items may be transported through a radioactive material use area provided that they are transported directly to an appropriate food and drink area; and,
5. Any items that may be perceived as evidence of noncompliance with this food and drink policy that are used for decorative or research purposes must be clearly marked with a statement indicating that they are not to be consumed or used for the consumption of food or drink.

Failure to comply with this policy may result in enforcement action based on the Radiation Safety Program Three Strike Policy (EH&S RSD RSP PS-01).

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UCLA Radiation Safety Program: Three Strike Policy

UCLA ENVIRONMENT, HEALTH & SAFETY

Research Safety Division
Radiation Safety Program
Three Strike Policy Memorandum*

501 Westwood Plaza, 4th Floor • Los Angeles, CA 90095
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The Radiation Safety Program conducts routine inspections of radioactive material and radiation-producing machine use laboratories and clinics on a quarterly, semi-annual, or annual basis. Additionally, the RSP interacts with these laboratory groups on a regular and frequent basis, aside from routine audits (*e.g.,* radioactive waste receipt). When noncompliance issues are observed and documented during audits or other instances, enforcement actions are taken to ensure compliance with federal and state regulations as well as university policies.

A "serious" radiation safety finding is a noncompliance issue involving a contamination incident, food and drink policy violation (in radioactive material use laboratories only), or personal protective equipment (PPE) policy violation and requires a repeat inspection within 48 hours of the finding. Failure to resolve a "serious" finding within 48 hours will escalate the significance of the event and requires reporting of the incident to the Office of Environment, Health & Safety (EH&S) Director, Department Chair, as well as the Associate Dean and the Dean of the respective school.

All other documented noncompliance issues require a repeat inspection by the RSP within 30 or 90 days, contingent on the nature of the finding. Contamination criteria are described in the Radiation Safety Manual. Related policy information may be referenced on the EH&S website under the Radiation Safety Documents and Forms link at www.ehs.ucla.edu.

Strike categories are defined below.

STRIKE ONE

When a repeat issue of noncompliance or an egregious violation has been identified by the RSP during an inspection or any other interaction with the radioactive material or radiation-producing machine use group, or during the RSP's review of the group's performance during the permit authorization period, a Strike One Memorandum may be issued. The memorandum will indicate the item(s) of noncompliance and request a response from the PI describing the corrective action(s) to be implemented. Failure to respond within the stated time period (30 days from the date of issue) may escalate the memorandum level to Strike Two. The Radiation Safety Officer (RSO) and the group's assigned health physicist (HP) shall review the adequacy of the response and offer guidance, as appropriate.

* Approved by Radiation Safety Committee on April 10, 2012.

STRIKE TWO

Documentation of the recurrence of a finding during the following problem-resolution inspection or any other interaction with the radioactive material or radiation-producing machine use group, or during the RSP's review of the group's performance during the permit authorization period, may result in the issuance of a Strike Two Memorandum. This notice will be sent to the PI informing him/her that this is a repeat item of noncompliance. The PI must provide a written response to the RSP as to the reasons why the previous corrective action(s) was/were ineffective and what further corrective action(s) will be implemented to prevent recurrence. Failure to respond within the stated time period (15 days from the date of issue) may escalate the memorandum level to Strike Three. The RSO and the responsible HP for the group will review the adequacy of the response and will offer assistance to the PI to ensure future compliance. A notice shall be sent to the Chair of the Radiation Safety Committee and the Department Chair to inform them of the potential for PI permit suspension.

STRIKE THREE

Documentation of the recurrence of a finding during the following inspections or any other interaction with the radioactive material or radiation-producing machine use group, or during the RSP's review of the group's performance during the authorization period, may result in the issuance of a Strike Three Memorandum. This notice will be sent to the PI informing him/her of the continuing noncompliance and the PI's permit will be suspended for 15 calendar days, pending concurrence by the Radiation Safety Committee. During the suspension period, the PI will be instructed to appear before the Radiation Safety Committee to explain why their permit should be reinstated.

NOTES:

1. The PI will be notified of noncompliance with the Three Strike Policy and potential penalties before institution of the penalties. It is expected that compliance will be achieved before the PI is requested to appear before the Radiation Safety Committee.
2. All Strike Memoranda will be effective for a period of 12 months. If a Strike Two Memorandum is issued during the 12-month period, the Strike Two level is reduced to a Strike One level at expiration of the initial Strike.
3. In the event of significant disregard for safety by a PI or the PI's associated laboratory group, the PI's radiation use permit may be suspended by the Radiation Safety Program, with concurrence of the Director of Environment, Health & Safety and the Radiation Safety Committee, without instituting the Three Strike Policy. Should this occur, the PI will be required to appear before the Radiation Safety Committee.
4. The Radiation Safety Manual contains a copy of the Three Strike Policy for ease of reference. This policy, and all other UCLA, EH&S, and RSP policies should be distributed to all laboratory staff members for assurance of compliance. The policy may also be referenced at the EH&S website at www.ehs.ucla.edu.

STANDARD GUIDANCE FOR WORKING WITH RADIOACTIVE MATERIALS

General Handling Precautions

- **Training:** Only personnel who have completed radiation safety training may use radioactive materials.
- **Personal Protective Equipment (PPE):** Wear appropriate PPE, including full length pants, closed toe shoes, gloves, lab coat and protective eyewear in the lab. Wear dosimeters if provided by EH&S.
- **Survey Equipment:** Use an appropriate survey meter and probe when working with radionuclides (other than H-3). Tritium can only be detected with a wipe test using a liquid scintillation counter (LSC).
- **ALARA:** Radiation exposures should be reduced to as low as reasonably achievable (ALARA) by employing the principles of time, distance and shielding.
- **Work in designated radioactive materials area:** Use designated benches covered with an absorbent liner. A certified fume hood should be utilized if working with volatile radioactive materials.

Radioactive Materials Storage

- **Labels and Shielding:** Clearly label each item in storage and properly indicate all storage and work areas. Ensure all materials in storage have adequate shielding.
- **No Food or Drink:** Do not store food in areas (including refrigerators) where radioactive material is stored or used. Do not eat, drink, smoke or apply cosmetics in areas where radionuclides are being used.
- **Secondary Containment:** Provide appropriate secondary containment for all liquid radioactive materials, including waste. A tray with a lip should be used to catch spills.

Radioactive Spill

- **Major** (≥100 uCi of non-alpha emitters; any amount of alpha emitters; or not contained in labs; or with the potential for personnel exposure): If life threatening injuries, dial **911** (or 310-825-1491 from cell phone) immediately. Evacuate all personnel from immediate area. Do not permit those directly involved with the spill from leaving the vicinity. Shield spill if necessary and isolate area. Survey personnel involved with spill using appropriate survey instrument. Remove any contaminated articles of clothing and place in plastic bags. Immediately call EH&S Hotline at **x59797**.
- **Minor** (<100 uCi of non-alpha emitters; and contained in labs; and with no personnel contamination): Cover spill with absorbent material and isolate area. Notify others in immediate vicinity. Begin decontamination efforts, if experienced. Wear PPE and clean using absorbent materials and cleanser, starting at lowest concentration of contamination working towards highest. Check gloves frequently and change when contaminated. Place all contaminated materials in radioactive waste bag. Monitor involved personnel with appropriate survey instrument and conduct final survey of area. If levels persist above acceptable limits (see Chapter 7), call EH&S Hotline immediately at **x59797**. Record incident in the laboratory survey log and contact EH&S at **x55689** for any further instructions.
- **Personal Contamination:** Immediately remove contaminated gloves and/or clothing. Rinse area, especially between fingers and around fingernails if hand contamination, with lukewarm water first then wash with mild detergent. Call EH&S at **x59797** for assistance or **911** (310-825-1491 from cell phone).

Radiation Safety Program Requirements

- **Radiation Safety Journal:** Log all receipts, uses, and disposal of radioactive material in the Radiation Safety Journal.
- **Transferred Materials:** Recipients of transferred materials must be authorized to receive the isotope intended for transfer. Both parties should have a copy of the transfer form and a copy must be sent to your responsible health physicist.
- **Monthly Surveys:** Contamination surveys using a wipe test must be performed on at least a monthly basis during the same calendar month in which materials were used.

Purchasing Radioactive Materials

- **Review your Radioactive Materials Permit**: Ensure you are authorized to receive the radionuclide and chemical form before ordering from the vendor. Contact your responsible health physicist for questions regarding your permit.
- **Order Placement:** Always include your lab's Radioactive Materials Permit (LA) number and Principal Investigator's name when placing your order.
- **Order Delivery:** All radioactive materials packages must be sent to the Radiation Safety Central Services Office. You must notify EH&S Radiation Safety immediately if your lab accidentally receives any radioactive materials directly.

<u>Note</u>: All fires, major spills and exposures must be reported to the EH&S Hotline at x59797 as soon as possible.

Revised 10/2012

UCLA ENVIRONMENT, HEALTH & SAFETY