

Radiation Safety Manual

UCSB Environmental Health & Safety

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*Section 1***Introduction to Manual and Radiation Safety Program**1.01 Radiation Safety Manual*Purpose*

The Radiation Safety Manual describes UCSB's management of ionizing radiation and establishes procedures related to radiation safety. The program and procedures described in this manual are also intended to facilitate compliance with the University's radioactive material license and applicable state and federal regulations. A copy of the radioactive material license and relevant regulations are available for review at Environmental Health and Safety (EH&S).

Scope

The program and procedures contained herein apply to all users of ionizing radiation at the University of California, Santa Barbara, and its various off-campus locations. The provisions and requirements outlined in this manual are an integral condition of the University's radioactive material license.

Distribution

Each permit (i.e., radiation authorization) holder who is authorized to use radioactive materials or radiation producing machines is assigned a copy of this manual. Permit holders are responsible for communicating the information in this manual to their laboratory personnel and maintaining current copies for review.

1.02 Radiation Safety Program

The purpose of the radiation safety program is to ensure that work with radioactive materials and radiation producing machines is conducted in such a manner as to protect the health and safety of personnel, minimize environmental and facility impacts and comply with the University's license and relevant regulations.

This program also incorporates the regulatory philosophy which seeks to keep all personnel radiation exposures "As Low As Reasonably Achievable, " (i.e, ALARA) given available social and economic resources. Fulfillment of the ALARA philosophy shall be, to the greatest extent practicable, consistent with the education and research mission of the University.

*Section 2***Organization and Responsibilities**2.01 Chancellor

The Chancellor of the University of California, Santa Barbara, directs that users of ionizing radiation comply with the University's radioactive materials license, the Bylaws of the Radiation Safety Committee, this Radiation Safety Manual, and applicable state and federal regulations.

2.02 Vice Chancellors

Through the Policy Statement on Environmental Health and Safety (Appendix A), the Vice Chancellors are responsible for ensuring that units under their authority comply with all applicable policies and procedures.

2.03 Radiation Safety Committee (RSC)

The Radiation Safety Committee is appointed by the Vice Chancellor of Administrative Affairs and is responsible for establishing and enforcing policies related to radiation safety. At least one member of the committee must approve any project involving ionizing radiation. This review ensures that the use of ionizing radiation is in keeping with regulatory requirements and the accepted practices of radiation safety.

2.04 Environmental Health and Safety (EH&S)

Environmental Health and Safety is responsible for developing safety education and monitoring programs to ensure compliance with campus Environmental Health and Safety policy. EH&S is authorized to inspect all areas of campus operations and activities.

EH&S Director

The EH&S Director is responsible for ensuring adequate resources and services are made available to the radiation safety program, for coordinating various program elements within EH&S, and communicating program needs to the Vice Chancellor.

Radiation Safety Officer (RSO)

The Radiation Safety Officer is responsible for managing the radiation safety program and for advising the Director, EH&S, on issues related to radiation safety. The RSO is Executive Officer of the Radiation Safety Committee (RSC), carries out the directives of

the Committee, refers matters to the RSC for review and approval, and advises on the overall status of the radiation safety program. Each application for an Ionizing Radiation Authorization (IRA) is reviewed by the Radiation Safety Officer and, if necessary, the full Radiation Safety Committee.

The RSO is vested with the authority, by the Director of Environmental Health and Safety, to order the cessation of activities posing an immediate or extreme radiation hazard to personnel.

2.05 Department Chair

The Department Chair reviews and grants concurrent approval, with the Radiation Safety Committee, of ionizing radiation use within each department. Such approval, as indicated via signature on the IRA certifies that operations will adhere to the policies of the Radiation Safety Committee, and that adequate resources will be provided to control potential radiological hazards associated with the use of ionizing radiation.

2.06 Permit Holders (i.e., Principal Investigator)

The permit holder is defined, for the purpose of this manual, as the individual who has signed, as applicant, either an "Application for Possession and Use of Radioactive Material" (Appendix B-2) or an "Application for Authorization to Use Radiation Producing Machines" (Appendix B-14).

Permit holders are ultimately responsible for ensuring compliance with the conditions and procedures specified in their individual Ionizing Radiation Authorizations, this Radiation Safety Manual, and all applicable policies of the Radiation Safety Committee. Major responsibilities of permit holders include:

- (a) Maintaining current records regarding:
 - (1) Radioisotope and radiation machine use;
 - (2) Results of monitoring surveys of their laboratories and work areas;
- (b) Having required records available for inspection at reasonable times by EH&S and state inspectors;

(To aid in the maintenance of records, a Radiation Safety Records and Resources binder has been established for radioisotope users. All required records should be kept in this binder.)

- (c) Establishing additional safety procedures and policies commensurate with the activities of their particular research group;
- (d) Training of all personnel (see Section 5) under their supervision in the proper safety procedures to minimize radiation exposure;

(Standards for radioactive contamination are detailed in Section 12. The campus' administrative levels and state regulatory limits for personnel radiation exposure are listed in Appendix C.)
- (e) Posting of the Ionizing Radiation Authorization within the work area, maintaining required warning signs and labels, and assuring the proper storage and control of radiation sources;
- (f) Enforcing the proper use, by individuals under their supervision, of personnel monitoring devices, survey meters, protective clothing and equipment, and other safety equipment as specified in their Ionizing Radiation Authorization;
- (g) Disposing of all radioactive waste in accordance with approved procedures of the Radiation Safety Committee (see Section 8);
- (h) Notifying the Radiation Safety Office prior to discontinuing work with radioactive materials or radiation machines or vacating laboratories listed in an Ionizing Radiation Authorization.

2.07 Individual Radiation User (Authorized User)

Each radiation user is responsible for keeping all radiation exposures to themselves and others as low as reasonably achievable (ALARA). To minimize personnel radiation exposures, users must know and observe the policies and procedures described in this manual, follow the precautions listed on the Ionizing Radiation Authorization, and immediately inform the permit holder, or supervisor, when unsafe conditions are known or suspected to exist. Individual users are also responsible for ensuring that they receive training as described in Section 5 of this manual.

*Section 3***Authorization to Possess and Use Radioactive Material****3.01 Application Procedure to Use/Possess Radioactive Material**

A completed “Application for Possession and Use of Radioactive Materials” form (Appendix B-2) must be submitted to EH&S and approved before radioactive materials can be received, possessed, or used. The applicant must also complete and submit to EH&S a “Permit Holder’s Statement of Training/Experience (Appendix B-15) form. Additional information may be requested from the applicant as it relates to the use of ionizing radiation. Depending on the proposed use, the application may require the review and approval of the full Radiation Safety Committee.

The applicant must also describe, in detail, the proposed use and location of radioactive material, the activity and radionuclide(s), frequency of usage, and the type of monitoring equipment available. The RSO should be consulted to assist in determining the monitoring equipment and methods appropriate for the radionuclide(s).

Applicant (Permit Holder)

The applicant must supervise the project involving radioactive material and is responsible for conducting the project safely by complying with conditions specified in the Ionizing Radiation Authorization (IRA). All policies and procedures established by the Radiation Safety Committee and included in the Radiation Safety Manual are to be followed.

Radiation Safety Coordinator

The permit holder of an IRA project should designate an individual who can assist the permit holder in maintaining laboratory records related to radiation safety, act as a direct contact with the Radiation Safety Office in the absence of the permit holder, and assist in other duties at the discretion of the permit holder. This individual must have adequate training and sufficient experience to function in the permit holder’s temporary absence (e.g. sabbatical, vacation, etc.). However, the ultimate responsibility for the IRA will remain with the permit holder.

Review/Approval of Application

The application is submitted to the RSO for review. If the RSO and, if necessary, the full Radiation Safety Committee approve the application, an Ionizing Radiation Authorization is issued. The IRA lists the radioactive materials and quantities authorized and any conditions specific to their use.

3.02 Ionizing Radiation Authorization

An IRA for radioactive materials usually expire every two years. In some cases, an IRA may be issued for shorter periods. The expiration date for a particular authorization is listed on the IRA.

Renewal of an IRA

A “Renewal of Ionizing Radiation Authorization” form (Appendix B-3) must be completed and submitted to the Radiation Safety Office, EH&S, prior to renewing an authorization.

The authorization must be renewed if:

- (a) work with radioactive material is to continue,
- (b) Radioactive material is to remain in possession of the applicant.

Continuation of an IRA

A completed “Continuation of Ionizing Radiation Authorization” form (Appendix B-4) must be submitted to EH&S by the permit holder one year after an IRA is issued or renewed. The continuation process allows the Radiation Safety Office to conduct an annual review of the authorization.

Amendments to an IRA

In certain cases, a permit holder may need to amend his/her IRA. Such instances are changes in room locations, modifications in the amount and/or type of radioactive material and other significant issues. To amend an IRA, information describing the nature of the amendment must be submitted to the RSO for review and approval.

IRA Termination

Depending on the nature of the violation(s), an IRA may be suspended or terminated by the Radiation Safety Officer, with the concurrence of the Radiation Safety Committee. The permit holder and the Department Chair will be notified when an IRA has been suspended or terminated.

Upon termination of an IRA, all radioactive materials must be transferred to Environmental Health and Safety. No radioactive materials may be transferred to another IRA without notification and approval of the RSO.

The permit holder must notify the Radiation Safety Office of their intention to terminate an IRA. Advance notification is necessary in order to permit scheduling of decommissioning functions.

*Section 4***Procurement, Custody, Transfer/Shipment of Radioactive Material**4.01 Procurement Policy

Procurement of all radioactive materials, whether by purchase, gift, or loan, must be reviewed and approved by the Radiation Safety Officer or designated alternate.

Requisition

Information for the purchase or receipt of radioactive material must include the following information:

- (a) The radionuclide, activity, and chemical form of material;
- (b) The IRA number;
- (c) Any special instructions for shipping and handling.

Delivery

All shipments of radioactive materials to the campus must be addressed and delivered directly to the "Radiation Safety Office, Building 565, University of California . . ." Upon receipt of the shipment, EH&S will monitor the shipment and deliver the material to the authorized user. (Note: Prior to disposal of an empty radioactive material shipping box or container, all radioactive material labeling must be removed or defaced by laboratory personnel.)

4.02 Custody of Radioactive Material*Accountability*

Authorized users are responsible for the custody of all radioactive materials in their possession. Authorized users must also ensure that all licensed materials in their possession are secure from unauthorized removal.

Acceptable methods of securing unattended radioactive materials are:

- (a) Locking the laboratory, and/or
- (b) Locking refrigerators or cabinets where these materials are stored.

Environmental Health and Safety must immediately be notified of the loss of any radioactive material.

Semiannual Inventory

Semiannually, EH&S sends to each permit holder a radionuclide inventory form. The permit holder, or designee, must inventory all materials within their possession, update this form, and return the information to EH&S by the specified due-date.

Failure to promptly perform the inventory and return the form may result in the suspension of approval to order and receive radioactive materials.

4.03 Transfer/Shipment of Radioactive Materials

All transfers of radioactive materials must be specifically approved by the Radiation Safety Office. In addition, all off-campus shipments of radioactive materials must comply with the requirements of the U.S. Department of Transportation (49 C.F.R).

Transfers Within Campus

No radioactive material may be transferred from one IRA project to another without the specific approval of the Radiation Safety Office. A completed "Record of Radioactive Material Transfer" form (Appendix B-5) must accompany all transfers and a copy sent to the Radiation Safety Office.

The unauthorized transfer of radioactive materials may result in the suspension of the Ionizing Radiation Authorization and impoundment of the materials.

Off-Campus Shipments

- (a) Shipments of radioactive materials to another campus or licensee must have the prior approval of UCSB's Radiation Safety Officer.
- (b) Packaging, monitoring, and labeling must be performed or inspected by Radiation Safety Personnel.
- (c) A copy of the recipient institution's radioactive material license must be on file at Environmental Health and Safety prior to shipment.

*Section 5***Training of Radioactive Material Users**5.01 Training of New Users

Permit holders are responsible for ensuring that every individual working under their authorization is fully instructed and knowledgeable in appropriate radiation safety practices.

On-the-Job Training

Campus Radiation Safety staff, permit holder, or designee, must instruct the new user in general campus radiation safety policies and any additional policies and/or procedures utilized within the particular research group. Both the instructor, or designee, and new user must document and certify this training by completing and signing a "Training and Experience Record for Radioactive Material Use" form (Appendix B-6). This training must be completed and documented, and the form submitted to the Radiation Safety Office, within thirty (30) days of the new user beginning work with radioactive materials.

Introductory Class in Radiation Safety

Individuals intending to work with radioisotopes must first attend a radiation safety orientation sponsored by EH&S Radiation Safety. The orientation consists of either attending the introductory new user radiation safety class in person (presented by a member of UCSB Radiation Safety) or through an online course approved by the campus RSO and Radiation Safety Committee.

5.02 Continuing Education*On-the-Job Training*

The permit holder is responsible for ensuring that all users under the IRA receive instruction in new and updated campus and research group radiation safety policies and procedures.

Annual Refresher Class in Radiation Safety

All continuing radioactive material users are required to annually attend a refresher training course. The Radiation Safety Refresher Class is offered online through the EH&S Radiation Safety Website (Only a campus RSO approved course will be seen as credit for this requirement). (During an IRA renewal, Radiation Safety audits the project and discusses relevant issues with the permit holder. Through the combination of this

process and personal endeavors the permit holder obtains required continuing education in current policies and procedural issues.)

*Section 6***Monitoring of Personnel for Radiation Exposure**6.01 Introduction

Environmental Health and Safety furnishes personal radiation monitoring devices and bioassay services when required by statute, Radiation Safety Committee Bylaws, or deemed desirable by the Radiation Safety Officer, as documented in the Ionizing Radiation Authorization. (Listed in Appendix C of this manual are the campus administrative levels and state regulatory limits for radiation exposure to personnel.)

6.02 External Dosimetry Procedures

Users are responsible for complying with IRA external dosimetry requirements and ensuring the proper use of radiation monitoring badges:

- (a) To obtain a radiation monitoring "badge," submit a completed "Request for Addition of Radiation Badge Service" (Appendix B-7) to the Radiation Safety Office. (Monitoring badges cannot be issued until badge request forms have been submitted to the Radiation Safety Office.)
 - (1) Assigned badges must be worn as specified in the ionizing radiation authorization;
 - (2) Users must wear only their personally assigned badge(s), and never share their badge(s) with another individual;
 - (3) Users must promptly return badges at the end of the monitoring period; failure to return badges or provide explanatory documentation (see Section 6.02b) in a timely manner may necessitate retraining to resume work with radiation sources;
- (b) Individuals who have lost or damaged their radiation monitoring badges must complete and submit to the Radiation Safety Office a "Record of Lost/Damaged Radiation Badge" form (Appendix B-9). The RSO will use this form to assess and document exposure during the monitoring period covered by the missing badge.
- (c) A "Request for Deletion of Radiation Badge Service" form (Appendix B-8) should be submitted when personnel no longer require badge service.

6.03 Internal Dosimetry Procedures

Users are responsible for complying with IRA internal dosimetry requirements and cooperating in assay procedures. The Radiation Safety Officer may also determine that bioassays are necessary to assess possible internal uptakes of radioactivity from documented laboratory accidents. Current university requirements include:

- (a) Users of unsealed ^{125}I , conducting experiments with individual quantities of 1 millicurie or more in a calendar quarter, are required to undergo a thyroid bioassay. The thyroid bioassay is conducted by Radiation Safety Personnel. The user is responsible for promptly notifying Radiation Safety each time 1 mCi or more of unsealed ^{125}I is used per calendar quarter.
- (b) Users of unsealed tritium (^3H), in larger quantities of activity (e.g., Curie), may be required to submit to a urine bioassay. The necessity for a bioassay will be determined by the Radiation Safety Office, which will consider the chemical form of the tritium, experimental protocol, and available engineering controls (e.g., fume hood). The Radiation Safety Office will notify the user if bioassays are required.
- (c) Users of various quantities of other radionuclides may require bioassays, depending upon the specific chemical form of the radionuclides, the activity handled, and the nature of operations.

6.04 Dosimetry Records

Personnel radiation dosimetry records are permanent records of Environmental Health and Safety. Upon written request, the Radiation Safety Office will advise individuals of their annual exposure to radiation as recorded in these records. All personal dosimetry records can be found online at dosimetry.com. The Radiation Safety Office will only contact users which have displayed dose rates that are elevated or appear inconsistent with stated radioactive material use. Upon leaving the University, an individual may request a copy of their exposure record, or that EH&S forward a copy to another institution. In addition, in any case where an individual's radiation exposure must be reported to the California Department of Health Services, that individual will be notified in writing of the nature and extent of their exposure.

6.05 Working With Radioactive Materials While Pregnant

If you are a radiation worker that is pregnant, or considering becoming pregnant, additional radiation safety information is available on the UCSB EH&S website if you wish to declare your pregnancy.

*Section 7***Radioactive Material Usage**7.01 Authorized Locations

Radioactive materials shall only be used at locations (e.g., laboratories, temporary field research sites, university marine vessels) specifically authorized in the Ionizing Radiation Authorization. In addition, the IRA may place restrictions on the specific radionuclides, chemical and physical forms, quantities, and operations that may be performed at a particular authorized location.

7.02 Location Posting

All rooms where radioactive materials are used or stored in an amount exceeding ten times the quantity listed in 10 CFR, Appendix C (see listing in this manual, Appendix E), shall be posted with the standard warning symbol (trefoil) and the words “CAUTION - Radioactive Material.” Radiation Safety will determine the appropriate types and placement of postings.

All locations where radioactive materials are used or stored shall be posted with a current copy of the Ionizing Radiation Authorization. For extended work areas (e.g., suites of laboratories), this requirement may be satisfied by posting the IRA at one location which is accessible to that authorization's designated radioactive material users.

Storage Areas

Storage areas of radioactive material shall be carefully chosen to control potential personnel radiation exposures and contamination and minimize risks associated with natural disasters and accidents (e.g., earthquakes, fires, hose streams/flooding). **No food or drink shall be stored in radioactive materials storage areas, nor in any part of a cold room or refrigerator that is posted for the storage of radioactive materials.**

The permit holder is responsible for ensuring that all location postings are maintained and easily visible.

“Notice to Employees”

California Department of Health Services form RH 2364, “Notice to Employees,” shall be permanently and conspicuously posted in a sufficient number where radiation workers can view this notice. (The notice is generally posted on the main floor bulletin board in buildings where controlled areas are present.) It is highly recommended that readers of this manual review the copy of the “Notice to Employees” included in Appendix D.

7.03 Restricted Areas

For purposes of radiation safety, access to certain laboratories and other locations shall be restricted to specifically authorized personnel who have received appropriate training and any necessary protective equipment. Some examples of "restricted areas," defining radiation conditions, and appropriate postings, are:

- (a) "Caution -- Radiation Area" if radiation levels exist in an area, accessible to individuals, such that an individual could receive a whole body dose equivalent in excess of 5 millirem in one hour at 30 centimeters from the radiation source;
- (b) "Danger -- High Radiation Area" if radiation levels exist in an area, accessible to individuals, such that an individual could receive a whole body dose equivalent in excess of 100 mRem in one hour at 30 centimeters from the radiation source;
- (c) "Grave Danger--Very High Radiation Area" if radiation levels exist in an area, accessible to individuals, such that an individual could receive an absorbed radiation dose in excess of 500 Rads in one hour at 1 meter from a radiation source.

It is the joint responsibility of the user and the permit holder to control access to such restricted areas. With the sole exception of being under the continuous monitoring and supervision of a trained and approved user, all such restricted areas shall be posted with the appropriate warning statement(s).

(Locked laboratories, storage cabinets, and/or barricades are usually considered to be the minimum acceptable control measures for unattended restricted areas. Warning lights and door interlocks/alarms are usually considered to be the minimum acceptable control measures for High and Very High Radiation Areas. Additional postings, such as "RESTRICTED AREA: Authorized Personnel Only," should be utilized when they will further reduce the chances of inadvertent entry into such areas.)

7.04 Controlled Areas

Controlled areas are areas outside of a restricted area, but inside of the licensee's (UCSB) site boundary, access to which can be limited by the licensee for any reason. For the purposes of this manual, controlled areas are laboratories posted with "Caution Radioactive Material" signs

7.05 Labeling of Containers, Areas, Equipment

Primary Radioactive Material Containers

Each container which directly holds radioactive materials is designated a "primary container." All primary containers shall be marked with the standard warning symbol (trefoil) and the statement "Caution-Radioactive Material." As an alternative to the labeling of primary containers, they may be placed within a larger, outer container (e.g., lead pig, tray, Plexiglas box, refrigerator shelf), provided that: (1) the outer container bears the standard warning symbol and statement; (2) written records which identify the radionuclides and activities in individual containers are readily available.

Contaminated Areas and Equipment

All potentially contaminated equipment (e.g., pipettes, centrifuges, trays) shall be labeled with the standard warning symbol and statement, or placed within equivalently marked containers, or placed within an established "exclusive use area" (see Section 7.05).

All equipment, containers, areas or items which were formerly used for radioactive materials work or storage, and which are therefore potentially contaminated, shall be surveyed, decontaminated if necessary, and have all warning labels removed or defaced before being released to uncontrolled (non-radioactive) use. Listed in Section 12 are the contamination and external radiation limits for releasing equipment for uncontrolled use.

Animals and Cages

Animals which have been administered radionuclides shall be caged and segregated from other animals. Such radionuclide animal cages shall be labeled with the standard radiation warning symbol and statement. In addition, the cage label should also include the name of the user responsible for the experiment, the radionuclide, activity and date of administration.

Cages that previously housed animals injected with radionuclides shall be surveyed for contamination by project personnel prior to their release for non-radioactive use (see Section 12).

7.06 Laboratory Practices

Multiple Use Work Areas and Equipment are those that are sometimes used with both radioactive and non-radioactive materials. Multiple use work areas and equipment must satisfy the contamination and dose rate criteria of listed in Section 12.02. Equipment used for radioisotope work located in multiple use work areas must be labeled with the standard radiation warning symbol and the statement: "Caution-Radioactive Material."

Exclusive Use Work Areas and Equipment are those that are only used with radioactive materials. To be designated for exclusive use, a work area must: (1) be posted with the standard warning symbol and statement; (2) areas must have clearly demarcated and easily recognizable boundaries (e.g., radioactive material tape); (3) not contain nonradioactive materials and/or equipment unless all such items are surveyed before removal from the designated area; and (4) only be used by those who have been trained in radiation safety as described in Section 5. Thus, exclusive use areas may exhibit contamination levels and dose rates up to ten times those allowed for multiple use work areas and equipment Sections 12.02 and 12.03. (Note: floors and sinks may only be designated as exclusive use areas upon the specific review and approval by the Radiation Safety Office.)

Contamination Control

Counter tops, walls and floors in areas where unsealed radioactive materials are used should have smooth, impermeable surfaces (e.g., unfinished concrete and grouted, unglazed tile are generally not acceptable).

Work with unsealed radionuclides are be performed over absorbent paper and/or trays, or other suitable covering, to help contain radioactive spills. Absorbent paper should be changed when torn, frayed or contaminated. Trays should be cleaned when dust or dirt becomes apparent, or contamination is detected.

Unsealed radioactive materials should be used, whenever possible, within a properly functioning fume hood. The use of a certified fume hood (air flow > 0.5 linear meters/second) may be required and listed on the IRA.

Radioactive liquids, powders and other readily dispersible forms of radioactive material shall not be transported into uncontrolled areas (e.g., hallways, elevators, between buildings) unless in a closed container which is impermeable and shatter-prove. In addition, it is good practice to utilize secondary containment whenever transporting such materials.

Radiation Shielding

Radioactive materials should be shielded if radiation levels exist in an area, accessible to individuals, such that an individual could receive a whole body effective dose equivalent in excess of 2 mRem in any one hour. Suggested shielding materials include:

- (a) Plexiglas, wood, or other low atomic number shielding for work with energetic beta emitters such as ^{32}P or ^{90}Sr . Such low atomic number materials should be used as an initial shield to reduce the production of more highly penetrating X-rays and bremsstrahlung."
- (b) Lead shielding for work with gamma and X-rays emitters such as ^{51}Cr or ^{125}I , or beta emitter produced bremsstrahlung. Lead bricks (5 - 10 cm thickness) are usually adequate for ^{51}Cr and higher energy (> 300 KeV) gamma emitters. Lead sheets (1 – 5 mm thickness) are usually adequate for ^{125}I and lower energy (< 100 KeV) photons and bremsstrahlung.
- (c) Hydrogenous materials, such as paraffin and water, for shielding high energy neutrons. Boron may be mixed with the primary hydrogenous shield to further reduce low energy neutrons and minimize the nuclear production of high energy gamma rays.

In keeping with the ALARA philosophy, shielding is recommended at less than the preceding levels if it is not unduly burdensome and it will appreciably reduce personnel radiation exposures. To further reduce personnel exposures, individuals should minimize the time spent around radiation sources and maximize their distance from these sources. The use of remote handling equipment (e.g., forceps, tongs) may be required and listed on the IRA.

Protective Clothing

Work with unsealed radioactive material requires the use of protective gloves. Laboratory coats are required to be worn, at a minimum, during opening of stock solutions, when performing iodinations and other hazardous operations. It is strongly recommended that personnel also wear clothing that completely covers their legs (e.g., long pants; long hem skirt) and some form of eye protection (e.g., safety glasses/goggles.) Additional personal protective equipment and/or garments, commensurate with the potential hazards, may be required as indicated on the Ionizing Radiation Authorization.

Personal Hygiene

Personnel shall not eat, drink, smoke, or apply cosmetics in radioactive material work areas, or otherwise make possible the ingestion of radioactive materials.

Individuals, upon completing their work with radioactive materials, should remove their gloves and check their hands for contamination. Monitoring of hands for contamination should be performed prior to washing them at uncontrolled sinks (e.g. rest rooms outside of radionuclide laboratories). In addition, it is strongly recommended that all personnel wash their hands before exiting unsealed radionuclide laboratories, regardless of their not having worked with such materials.

Cleaning of Contaminated Equipment

The cleaning of contaminated equipment (e.g., glassware for reuse) shall be performed in radioactive material work areas or other controlled areas. If radioactive solutions may be produced, cleaning should be performed in properly posted (i.e., radioactive material warning labels) buckets or trays.

Cleaning solutions and rinses from contaminated items shall be sampled for radioactivity prior to disposal. Rinses which are less than 3 times the background count rate, as measured in a liquid scintillation counter, can be considered "non-radioactive" and, provided no other hazardous chemicals are present, may be released into the sanitary sewerage system.

Materials Use Records

Written records shall be maintained of all uses of radioactive materials. These records shall include, at a minimum, the name of the user, the particular radionuclide, its chemical form, and the specific quantities and dates of use of the material.

Radiological Survey Instruments

Permit holders and users shall ensure that laboratory and portable radiological survey instruments are functional and within calibration. A calibration label, indicating the date of the last calibration and its effective duration, shall be affixed to all portable instruments.

Survey instruments which are not fully functional and within calibration shall not be used until they have been repaired and/or calibrated. Such instruments should be clearly marked as to their "inoperative" status and taken out of service.

The Radiation Safety Office, EH&S manages a portable survey instrument tracking system, and assists in arranging repairs and calibrations. Radiation Safety is usually able to provide a "loaner" instrument. To utilize these services, authorized users should:

- (a) Inform the Radiation Safety Office whenever such portable instruments are purchased or otherwise brought onto the campus;
- (b) Inform the Office when portable instruments are in need of repairs;
- (c) Provide necessary funds for repairs and scheduled calibrations;
- (d) Provide access to laboratories and instruments.

Laboratory Surveys

A radiation survey of external dose rates may be required whenever radioactive materials are used. In addition, users of unsealed radioactive materials should monitor for potential contamination whenever such materials are manipulated.

Regular users of unsealed radioactive materials shall conduct a formal (i.e., documented) radiological health survey within each calendar month of use. When unsealed materials are used less frequently than monthly, a formal survey shall be performed within thirty days of last use. The formal survey shall include the monitoring of external dose rates, when appropriate, and the measurement of potential surface contamination, using appropriate techniques and instrumentation, in all individual and common work areas wherein unsealed radioisotopes are actively used. "Wipe" samples analyzed by liquid scintillation counting are required for areas where ^3H has been used. In addition, wipe samples are highly recommended for all radionuclides, especially for difficult to detect radionuclides such as the low energy beta emitters ^{14}C and ^{35}S , and electron capture species such as ^{51}Cr and ^{125}I . Potential contamination with ^{125}I may also be effectively monitored with a thin crystal NaI(Tl) probe. (See Section 12 for contamination limits in uncontrolled and exclusive use areas.)

The results of formal surveys, any corrective actions (e.g., shielding, decontamination), and confirmatory follow-up surveys, shall be recorded and maintained by laboratory personnel for periodic inspection. Additional records, and/or more frequent surveys, may be required and listed on the IRA. Radiation Safety Records and Resources binders are provided for record-keeping purposes.

7.07 Inspections/Surveys by Radiation Safety

Radiation Safety Personnel will conduct periodic inspections and audits of radioactive material users. During the course of these inspections, policy and procedural violations may be found which require corrective actions by the authorized user. Follow-up inspections will then be conducted by Radiation Safety to verify that corrective actions have been successfully implemented. Copies of inspection results will be sent to the permit holder responsible for the authorization.

Authorizations which have repeat violations and/or fail to implement corrective actions may be terminated upon review by the Radiation Safety Committee.

7.08 Leak-Testing of Sealed Radioactive Sources

Sealed sources containing in excess of 100 microcuries of beta/gamma, or 10 microcuries of alpha, emitting radionuclides shall be regularly tested for leakage. The Radiation Safety Office, EH&S, will perform the leak-testing. Authorized users shall provide Radiation Safety personnel with timely access to such sources. Radiation Safety shall remove from service, as required by the California Department of Health Services, sources leaking greater than 0.005 microcuries. The RSO may also require procedural or engineering controls for those sources that are found to be leaking at levels less than 0.005 microcuries.

7.09 Environmental Health and Safety Notification

In the event that extensive contamination or unexpectedly high exposures occur during the conduct of an experiment, it is the responsibility of the user permit holder to immediately notify the Radiation Safety Office. Advanced notification of Radiation Safety is required if it is anticipated that a procedure may result in these conditions or any other unusual hazard.

*Section 8***Radioactive Waste Disposal**8.01 Waste Containers and Disposal - General

Radioactive waste containers must be of the type supplied or approved by the Radiation Safety Office. The minimum criteria are that waste should have at least two separate layers of unbreakable containment and be clearly marked as to its radioactive contents. Examples would be a plastic carboy and spill/drip tray for liquid waste, a heavy duty plastic bag and cardboard box for solid waste, etc.

Pickup and disposal of radioactive waste is requested by submitting to the Radiation Safety Office, through the campus mail or through our website, a "Radioactive Waste Pickup Request" form (Appendix B-10). This form must be completed and submitted prior to pick up; requests by telephone are unacceptable.

All radioactive waste must be carefully prepared in compliance with campus procedures. Waste which fails to meet these minimum requirements may be refused pickup or returned to generating laboratories for additional preparation.

All radioactive waste must be disposed of through the Radiation Safety Office. The transfer of any radioactive solids to regular refuse containers or radioactive liquids to laboratory sink drains is strictly prohibited. This includes the storage for decay of short-lived radionuclides (e.g. P-32) by lab personnel and subsequent disposal as "non-radioactive" waste within the research lab.

The following waste categories (solid, liquid, liquid scintillation vials, animal) are separate and mutually exclusive.

8.02 Solid Waste Preparation*Definition*

Solid waste consists of dry, radioactively contaminated materials (typically paper, plastics, glassware and gloves).

Prohibited Materials

Although small amounts of damp materials may be unavoidably present, solid waste must not contain any free-standing liquids. (Free-standing liquid is that amount which can readily run, and thus could easily be emptied from centrifuge tubes, pipettes, etc.; it is not droplets retained in containers by surface tension or capillary action.)

Massive, non-compactable items (motors, centrifuges and heads, etc.) shall not be placed in solid waste receptacles. (Contact Radiation Safety for specific disposal procedures.)

Solid waste must not contain hazardous chemicals and materials (EPA-RCRA) such as lead pigs, stock vials with remaining liquids/powders, or sealed radioactive sources. (Contact Radiation Safety for specific disposal procedures)

Controlled Materials

Small quantities of non-integral radioactive solids (e.g., dusts, powders, fibers) must be sealed within plastic bags or plastic containers such as centrifuge tubes before being placed into solid waste receptacles. (Contact Radiation Safety when disposal of larger quantities of such materials is necessary.)

Sharp objects, such as razor blades, needles, and broken glass, must be placed within puncture resistant containers before being placed into waste receptacles.

Biohazardous materials must be sterilized before being placed into waste receptacles. (Under no circumstances are animals, associated excreta, or tissue samples to be placed into solid waste receptacles.)

Radionuclide Segregation

All solid waste must be segregated into three classes of receptacles, based upon the half-lives of contaminating radionuclides:

" $T_{1/2} < 14$ days" Radionuclides with half lives of 14 days and less (e.g., P-32, In-111, etc.) **All radioactive markings and symbols must be removed or obliterated.**

" $T_{1/2} < 90$ days" Radionuclides with half lives of 90 days and less (e.g., S-35, I-125, Cr-51, P-33, etc.), whether alone or combined with shorter-lived isotopes from multiple label experiments. **All radioactive markings and symbols must be removed or obliterated.**

"All Isotopes" Radionuclides with half-lives greater than 90 days (e.g., H-3, C-14, etc.), whether alone or combined with shorter-lived isotopes from multiple label experiments.

8.03 Liquid Waste Preparation

Definition

Liquid waste may consist of a variety of chemical constituents, provided that the waste is homogeneous, is "pourable," and is segregated by radioactive half-life.

Prohibited Materials

Although small amounts of non-soluble materials may be unavoidably present, liquid waste should generally not contain solid materials, especially plastic laboratory equipment such as pipette tips, microcentrifuge tubes, etc. (Indicate on the waste pickup form if the waste does contain solids and/or precipitates.)

Controlled Materials

Biohazardous liquids must be sterilized before being placed into waste containers. (Under no circumstances are animal excreta or homogenized tissue samples to be placed into liquid waste containers; these should be disposed of according to animal disposal policies.)

Small volumes of high concentration radioactive liquids (e.g., stock solutions) should not be placed into liquid waste containers. Instead, such liquids should be capped and stored separately for receipt and disposal by the Radiation Safety Office.

Voluntary Chemical/Physical Segregation

The generation of radioactive organic and/or hazardous materials (EPA-RCRA) solutions is strongly discouraged. When generation of such organic/hazardous waste solutions is unavoidable, it is preferable to segregate them from non-hazardous aqueous solutions.

Note: Although polymerized acrylamide may be present, liquid waste containing such material must meet the basics standards of being homogeneous and pourable; solutions which are not homogenous throughout the volume of the container may be returned to generators for separation.

In all cases, radioactive waste must be fully and accurately described on waste pickup forms.

Radionuclide Segregation

All liquid waste must be segregated based upon the half-lives of dissolved radionuclides:

" $T_{1/2} < 14$ days" Radionuclides with half-lives of 14 days and less (e.g., P- 32, In-111, etc.)

" $T_{1/2} < 90$ days" Radionuclides with half-lives of 90 days and less (e.g., S-35, I-125, Cr-51, P-33, etc.), whether alone or combined with shorter-lived isotopes from multiple label experiments. "All Isotopes" Radionuclides with half-lives greater than 90 days (e.g., H-3, C-14, etc.), whether alone or combined with shorter-lived isotopes from multiple label experiments.

8.04 Scintillation Waste Preparation

Definition

Scintillation waste consists of liquid scintillation cocktails (including dissolved or suspended samples), autoradiography enhancement solutions, and associated containers such as used counting vials.

Campus policy defines all scintillation waste to be radioactive, regardless of nondetectability of radioactivity. All such waste must be disposed of by the Radiation Safety Office.

Packaging

Scintillation waste shall be packaged for pickup as either vials in the original holding trays, bulk vials in plastic-lined fiberboard boxes, or bulk liquids in original containers or carboys supplied by the Radiation Safety Office.

8.05 Animal Waste Preparation

Definition

Animal waste consists of carcasses, tissue samples, and excreta which may contain radioactive materials. Prior to generating radioactive animal waste, the experimental protocol must be reviewed and approved by the Radiation Safety Office, EH&S.

"Non-Radioactive" Animal Waste: Contains H-3 and/or C-14 at a combined concentration of less than 0.05 uCi / gram, averaged over the entire mass of the animal carcass, tissue, and/or excreta. Such waste may be disposed of through regular campus procedures and animal waste contractors, provided that written records are maintained of pertinent radionuclides, activities, and waste masses.

Radioactive Animal Waste: All animal waste that does not qualify as non-radioactive on the basis of combined H-3 and C-14 concentrations. Animal waste within this category must be disposed of as radioactive waste.

Preparation for Radioactive Disposal of Animal Waste

Animal waste must be carefully prepared before pickup by Radiation Safety Personnel:

- (a) All biohazardous waste must be sterilized;
- (b) All waste must be double bagged or placed inside airtight plastic containers;
- (c) All waste must be either completely frozen or dry at the time of pickup.

8.06 Miscellaneous Waste Preparation

Contact the Radiation Safety Office for detailed instructions concerning the disposal of radioactive materials which do not fall within the categorical definitions of solid, liquid, scintillation media or animal waste. (This is especially important during the planning of new protocols which may generate large volumes of such waste.)

One broad class of such miscellaneous waste includes items such as lead pigs, stock vials (with or without remaining activity), high concentration solutions (≥ 100 uCi / cm³), and radioactive sealed sources.

*Section 9***Use of Ionizing Radiation for Academic Instruction**9.01 Authorization Procedure

A completed "Application for Possession and Use of Radioactive Materials" (Appendix B-2) or "Application to Use Radiation-Producing Machines" (Appendix B-14) must be submitted to Radiation Safety for authorization to use ionizing radiation as part of academic instruction. An approved Ionizing Radiation Authorization (IRA) for academic instruction is usually valid for only one quarter. Authorization for additional academic quarters may be requested by completing and submitting a "Renewal of Ionizing Radiation Authorization for Academic Instruction" (Appendix B-11) to Radiation Safety.

In certain instances, due to radiation safety concerns, a minimum ratio of laboratory assistants to participating students may be specified as a condition of application approval.

9.02 Training of Students

Students working near or with radiation sources must be instructed in the proper techniques and procedures associated with ionizing radiation use. This instruction is the primary responsibility of the IRA applicant. The following information must be submitted to the Radiation Safety Office by the course instructor:

- (a) Names of students attending the radiation safety instruction;
- (b) Date(s) of instruction
- (c) Outline of radiation safety topics covered during instruction

(If the course instructor prefers, the Radiation Safety Office may be contacted to arrange a presentation on radiation safety to the students.)

*Section 10***Radiation Producing Equipment**10.01 Description

Radiation producing equipment includes X-ray fluorescence, X-ray diffraction, cabinet radiography, accelerators, field radiography machines, medical radiography machines, and electron microscopes. Other machines may qualify depending on the intended application of the radiation produced.

All such radiation producing machines must be registered with the California Department of Health Services within 30 days of acquisition. Contact Radiation Safety in advance of purchase or disposal.

10.02 Authorization Procedures

Individuals procuring radiation producing equipment must complete and submit to EH&S an "Application for Authorization to Use Radiation-Producing Machines" form (Appendix B-14). Depending on the machine type and proposed use, the application may require the review and approval of the full Radiation Safety Committee.

An "Ionizing Radiation Authorization for Radiation-Producing Machines" (Appendix B13) is issued to a user whose application has been approved. The IRA for radiation producing machines describes the operating parameters of the machine, name of authorized user, personnel dosimetry requirements, and controls related to machine use.

10.03 Machine Use Requirements*Training*

For each specific machine used, radiation producing machine operators must be trained and familiar with the machine's engineering controls, administrative procedures and policies related to machine safety. This On-the-Job-Training must be documented on the "Training and Experience Record for Radiation Producing Machine Use" form (Appendix B-12). This form must be completed for each individual user prior to working with ionizing radiation producing machines. All training record shall be retained by the authorization holder and be available for EH&S review.

In addition, all analytical X-ray machine users attend an EH&S sponsored X-ray safety course. Contact the Radiation Safety Office for more information.

Operator Safety

Operators who use a machine under an IRA must maintain an operational guide specifically designed for their particular machine. Each individual assigned responsibility for operating the machine must be thoroughly familiar with the operational guide prior to assuming duties as an operator. The operation guide and safety instructions for each machine shall be posted nearby or made readily available for review. In order to prevent operation of a machine by unauthorized personnel, positive control of the machine must be maintained at all times. This may be in the form of a key or computer password which is required to energize the machine.

A use log for each machine must be maintained and made readily available for review. The use log includes information regarding the machine operator, date of operation, tube current, and voltage. Additionally, a current list of users authorized to operate the machine must be posted near the machine or readily available.

When working with an accessible beam, machine adjustments should be made, whenever possible, with the beam off or shutters closed. No modifications in the operational safety features may be made unless these have received prior approval of the Radiation Safety Office, EH&S. No part of the body should be within 3 inches of the main beam or high-level scatter. Shielding the beam with an interlocked enclosure is strongly recommended. Fail-safe warning lights, which warn of the production of X-rays, must also be clearly visible and installed near the beam shutter and the control console. Personnel not involved in machine operation should not be in close proximity to the machine. If required by the IRA, radiation monitoring badges must be worn by operators during machine operation.

Posting/Labeling

A current copy of the IRA must be visibly posted near the radiation producing machine. The State of California Dept. of Health Services "Notice to Employees" must be displayed in a conspicuous location where machine users may observe it on their way to or from work. EH&S approved "Caution: X-ray" stickers or signs must be posted on all entrances to the room(s), near the machine key switch, and near the tube head or shutter(s).

Radiation Surveys

Prior to use, newly acquired machines will be surveyed by Environmental Health and Safety in order to determine the effectiveness of shielding and other engineering and procedural controls. EH&S will also conduct an annual radiation survey and inspection of machines. Radiation survey measurements of machines should also be conducted whenever major repairs or tube replacements have been made. It is recommended that a

radiation survey meter be kept nearby to survey for scatter radiation and to verify that Xrays are being generated.

10.04 Disposal or Transfer of Machines

Environmental Health and Safety must be notified prior to disposition, transfer of ownership, or change in machine location. The State Department of Health Services must be notified within 30 days of changes in machine status.

10.05 Exemptions

Users of electronic products which produce X-rays only incidental to operation may, depending on the product and/or the results of radiation survey measurements, may be exempted from the issuance of an IRA. Such exemptions may include electron microscopes (scanning electron microscopes), ion-implanters, and cathode ray tubes. Users of exempted machines are not obliged to comply with the training requirements detailed in Section 10.03.

*Section 11***Emergency and Spill Procedures****11.01 Medical Emergencies***Serious Physical Injury with Possible Radioactive Contamination*

If radioactive contamination is associated with a serious physical injury, then prompt medical attention and hospitalization take precedence over all other concerns.

- (a) Consistent with your first aid training and experience, undertake immediate measures to prevent loss of life or serious disability (e.g., cardiopulmonary resuscitation, artificial respiration, establish an adequate airway, control significant bleeding).
- (b) **Dial 9-911** and report the accident to the dispatcher. Request an ambulance and describe the nature of the injuries. Inform the dispatcher if radioactive materials may be involved and request that Environmental Health and Safety be notified at **ext.3194**.
- (c) Consistent with stabilizing the patient's condition, survey the person to determine the nature and extent of possible radioactive contamination.
- (d) Advise emergency responders (e.g., firefighters, paramedics, emergency room personnel) if the patient is contaminated with radioactive materials.
- (e) Be prepared to accompany the patient with a radiation monitoring instrument and personal protective equipment; provide assistance that may be requested by emergency medical personnel.

11.02 Personnel Radiation Exposure and Contamination*Significant External or Internal Radiation Exposure*

Whenever unanticipated personnel radiation exposure or any ingestion is known or suspected to have occurred, undertake the following actions:

- (a) Note all important parameters relating to the exposure (e.g. location of individual and time spent near the source, levels of radiation, radionuclides and chemical forms, possible modes of ingestion);

- (b) Notify Environmental Health and Safety at **ext. 3194** (24 hour line).
- (c) Retain the radiation monitoring badge of the individual for immediate processing.

Skin Contamination

Skin contamination should be treated by initially washing the area with copious amounts of water and mild soap. Skin decontamination should be performed inside of a radioisotope laboratory. To minimize the spread of contamination, avoid using public rest rooms.

- (d) If the skin is broken or abraded, immediately flush the wounded area with water.
- (e) Immediately contact Environmental Health and Safety at **ext. 3194** (24 hour line).
- (f) Wash the contaminated area with soap and luke warm water for 2 to 3 minutes. Avoid abrasive soaps and organic solvents that may damage the skin or dissolve protective natural oils.
- (g) Monitor the skin to determine levels and location of contamination. Use a portable radiation survey meter for most radionuclides; take wipe samples and count them in a liquid scintillation counter for H-3 and I-125 contamination.
- (h) If contamination persists, repeat the washing and monitoring procedures several times, being careful to not damage the skin.
- (i) Collect any contaminated clothing or personal possessions in plastic bags for later monitoring.

11.03 Spills of Radioactive Materials

- (a) Inform all personnel in the laboratory that a spill has occurred. Limit and contain the spill by covering with absorbent pads or paper towels. Evacuate personnel to nearby safe areas.
- (b) **Monitor all potentially contaminated personnel. Do not allow potentially contaminated personnel to leave the area.**
- (c) EH&S should be contacted at **ext. 3194** to advise on decontamination techniques and determine the effectiveness of decontamination.
- (d) Don appropriate personal protective equipment (e.g., laboratory coats and leg coverings, gloves and shoe covers, safety glasses or face shields, etc.).

- (e) Monitor to determine locations and levels of contaminated areas. Mark the boundaries of contaminated areas with “Caution-Radioactive Material” tape. Keep non-essential personnel away from these areas.
- (f) Formulate a decontamination plan and assemble necessary supplies such as additional gloves, soap and brushes, absorbent paper, and radioactive waste containers.
- (g) Generally, decontaminate the least contaminated areas first. Avoid using large amounts of water since this may spread contamination. Frequently monitor spill area to determine effectiveness of decontamination. Document results of decontamination for inclusion into your laboratory survey records.

*Section 12***Standards for Contamination and Release of Equipment****12.01 General Philosophy and Purpose**

Radioactive surface contamination can present a range of personnel risks, ranging from external exposure, possible skin contamination and ingestion, to inhalation of resuspended materials. To ensure the safety of University personnel and the general public, and to prevent possible interference with experimental procedures and conserve property resources, surface contamination of all public and laboratory areas must be maintained as low as reasonably achievable (ALARA).

12.02 Contamination Limits -- Multiple-Use Work Areas

A good-faith effort must be made by research personnel to decontaminate areas and equipment to the lowest level practically feasible. Contamination is generally considered present when the count rate is three times above the background count rate using a suitable radiation monitoring device (e.g., Geiger counter, liquid scintillation counter, etc.).

The following contamination limits apply to areas and equipment which are not for the exclusive use of radioactive materials:

Type of Contamination	Removable Contamination (dpm/100 cm ²)
3H	≤ 400
14C/35S	≤ 250
Other beta emitters	≤ 100
Gamma emitters	≤ 100
Alpha	≤ 20

Areas or equipment exceeding the levels in the above table require decontamination.

For fixed contamination, radiation shielding of the area may be required to reduce exposure to personnel. See Section 7 for radiation shielding requirements.

12.03 Contamination Limits -- Exclusive-Use Work Areas

For properly labeled areas and equipment (e.g., fume hoods, centrifuges) used exclusively with radioactive materials, the contamination limits are ten times (x10) the limits specified for multiple use work areas and equipment (Radioactive materials users remain responsible for controlling radiation dose rates resulting from surface contamination.). A good faith effort should be made to reduce contamination in all areas to a level as low as reasonably achievable.

12.04 Uncontrolled Release of Equipment and Areas

Laboratory equipment which has been used with radioactive materials, or which may be reasonably suspected of being contaminated, shall not be transferred to uncontrolled use (e.g., no longer used incidental to radioactive material work or removed from a radioisotope lab) without first being surveyed and decontaminated to the lowest level practical or to the Multiple-Use limit in Section 12.02, whichever is lower. Decommissioned equipment shall have all radioactive materials warning statements and symbols removed.

Uncontrolled areas (e.g., areas outside of radioactive material labs or radioactive material labs which are decommissioned) will be, to the extent practical, decontaminated to the levels indicated for "Multiple-Use" areas. However, in some cases as determined by the Radiation Safety Officer, guidelines of the California Radiologic Health Branch for the free-release of facilities and equipment may substitute for the levels specified in Section 12.02 of this manual.

Potentially contaminated laboratory equipment which is being transferred to organizations outside the University (e.g., manufacturers, repair shops, calibration laboratories) shall be surveyed to ensure compliance with the receiver's own contamination standards, or the University's, whichever is lowest.