

# California Institute of Technology

## RADIATION SAFETY MANUAL



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# CHAPTER 1: GENERAL INFORMATION

## 1.1 INTRODUCTION

### PURPOSE

This manual provides information about the radiation protection program at Caltech.

### CALIFORNIA RADIOACTIVE MATERIALS LICENSE

A license to possess and use radioactive material has been issued to the California Institute of Technology (Caltech) by the California Department of Public Health - Radiologic Health Branch (RHB). It is a "Type A Broad Scope" license which allows for considerable flexibility required at a dynamic research center such as Caltech. As such, it requires Caltech to maintain a well-managed and documented radiation protection program to ensure that radioactive materials are used safely.

The license contains the information needed to use radioactive material in accordance with Caltech policies and California regulations. Copies of the license and California Radiation Control Regulations (CRCR) are available for review and inspection at the Environmental Health and Safety (EH&S) Office.

Under the terms of the license, the Radiation Safety Committee (RSC) is delegated the responsibility for authorizing qualified individuals to use radioactive material.

### RADIATION PRODUCING MACHINE REGULATIONS

Radiation-producing machines are registered with the RHB in accordance with the CRCR. The RSC approves the use of radiation-producing devices. For more details, see the Caltech [X-ray Safety Manual](#).

## 1.2 RADIATION SAFETY COMMITTEE

### PURPOSE

The RSC is appointed by the President of the Institute. It is responsible for ensuring that radioactive materials and radiation-producing devices are used safely and in accordance with state and federal regulations as well as Institute policies.

### RESPONSIBILITIES

The Committee is responsible for:

- Formulating general policy governing the use of radioactive material and radiation-producing equipment.
- Reviewing and approving all requests for the possession and use of radioactive material and radiation-producing devices at all Caltech locations, including any proposed alterations and new construction.
- Verifying that all individuals authorized to use radioactive material and radiation-producing machines have sufficient training and experience to conduct their duties safely.
- Establishing a program to ensure that all individuals whose duties may require them to work in the vicinity of radioactive material or radiation-producing equipment are properly instructed about all appropriate health and safety matters.
- Conducting an annual review of the radiation protection program to determine that all activities are being conducted safely and in accordance with CRCR and the Institute's license.
- Advising the President and Administrative Officers on current matters involving the use of

radioactive material and radiation-producing machines.

## MEETINGS

The RSC meets once every calendar quarter.

## MEMBERSHIP

RSC members include:

- Faculty members (appointed Division Radiation Safety Officers) with expertise in the use of radioactive material or use of radiation-producing devices.
- The Institute Radiation Safety Officer (RSO) who also serves as the Executive Officer.
- The Senior Director of the Environmental Health and Safety (EH&S) Office, a representative of administration.
- Other members shall be appointed at the discretion of the President.

## SUBCOMMITTEE

As members of the RSC, Division Radiation Safety Officers (DRSOs) serve as the primary point of contact regarding radiation safety matters within a division.

Except for uses requiring full committee approval (see [RADIOACTIVE MATERIAL USE APPROVAL](#)), the DRSO and the RSO form a subcommittee to review and approve applications and amendments involving routine use of radioactive material and machine-produced radiation.

## REPORTS AND RECOMMENDATIONS

Reports and recommendations of the RSC are directed to the Associate Vice President (AVP) of Facilities and the President as appropriate.

## 1.3 INSTITUTE RADIATION SAFETY OFFICER AND OTHER STAFF

### INSTITUTE RADIATION SAFETY OFFICER

The RSO is appointed by the AVP of Facilities. In addition to responsibilities as a RSC member, the RSO directs the Radiation Safety Program.

### RADIATION SAFETY STAFF

Under the direction of the RSO, the staff of the EH&S Office:

- Assist in developing general policies for control of radiation.
- Conduct training in the safe use of radioactive materials and radiation-producing machines.
- Evaluate equipment and facilities, including the testing of containment systems such as fume hoods and glove boxes.
- Evaluate operational techniques and procedures.
- Conduct surveys for contamination control in laboratory areas where unsealed radioactive materials are handled.
- Perform environmental monitoring of areas involving use of radioactivity or radiation.
- Respond to emergencies and investigate accidental doses.
- Provide advice on decontamination following spills or prior to modification of facilities or equipment.
- Issue personnel dosimetry devices.
- Perform bioassay analysis for internal deposition of radioactivity.
- Test sealed radioactive sources for leakage.
- Receive and inspect packages containing radioactive material.

- Prepare outgoing shipments of radioactive materials in accordance with current federal and state regulations.
- Pick up and process radioactive waste.
- Calibrate portable radiation survey instruments, alarmed dosimeters and installed detectors.
- Aid in completing the application for a permit to use radioactivity and furnishes consulting services.
- Maintains all pertinent records for license inspection.
- Aids in completing the application for a permit to use radioactive material and furnished consulting services.

# CHAPTER 2: AUTHORIZATION TO USE RADIOACTIVE MATERIAL

## 2.1 INTRODUCTION

### APPLICATION

Faculty members who wish to acquire and use radioactive material must submit an *Application for Possession and Use of Radioactive Materials* form to the RSC via the DRSO. A personal statement of training and experience in the use of radioactive material must accompany the application form for a new Principal Investigator (PI). These forms are available from EH&S Office or its website (safety@caltech.edu).

Each application must be completed in sufficient detail for the Committee's evaluation:

- Applications must include the name of the PI, the radionuclide, the chemical or physical forms, the amount for use per experiment and the maximum daily order limits.
- An experiment protocol must accompany each application, describing precautions to avoid the inadvertent release or ingestion/inhalation of radioactive material.
- Name any hazardous chemicals and compounds in addition to the radionuclide that will be used in your experiment.
- The RSC may require additional information such as facility design, type of radiation detection equipment, emergency procedures, waste disposal methods, and any relevant training and experience of personnel.

Applications for permits and a guide to complete them are available from the EH&S Office. The Radiation Safety staff will assist applicants in completing forms.

### AMENDMENT TO PERMIT

A request for amendment to an approved application is submitted as above on the form *Request for Amendment to Permit for Possession and Use of Radioactive Materials* available from the EH&S Office or its website. Amendment requests may be made only for the following changes:

- Chemical/physical form
- Daily order limit
- Location of use
- Use procedure.

## 2.2 RADIOACTIVE MATERIAL USE APPROVAL

### PERMIT AUTHORIZATION

All applications for the use of radioactive materials are reviewed by the RSC or the sub-committee. Upon approval, a numbered permit is issued, listing any special conditions specified by the RSC. The permit number is to be used when ordering materials, and when amending or renewing the permit.

### APPROVAL BY THE SUBCOMMITTEE

The RSC has designated the RSO and the DRSO in the applicant's academic division as a sub-committee authorized to approve applications considered to be routine in nature.

### APPROVAL BY FULL COMMITTEE

The following specific uses are considered to be major and will require review and approval of the entire RSC.

- Applications for acquisition of hazard class I nuclides in quantities greater than 100 microcuries and hazard class II nuclides greater than 1 millicurie ([See APPENDIX A](#) for classification).
- Applications for experiments or projects which involve substantial airborne hazards from gases, fine powders, or aerosols.
- Applications for new installations or for major modifications to existing facilities involving the use of ionizing radiation sources.
- Applications which the RSO or the DRSO feel should be brought to the attention of the full committee.

NOTE: It will generally take a minimum of two to four weeks to arrange for RSC approval.

## ANNUAL RENEWAL OF PERMITS

Radioactive material use permits are valid for three years but must be renewed each year before March 31st.

Sixty days prior to that date, the EH&S Office will send an annual renewal form to each PI. This form will identify the status of each permit.

When completing this form, you should:

- Review all information on this form for accuracy.
- Indicate the status of each permit and if changes are to be made in location of use or the use procedure. (Amendment request must be submitted for these changes.)
- Perform a physical inventory of your unused radioactive materials and provide an accurate inventory for each permit.
- Submit a new application form for permits that will expire on March 31st.
- Indicate disposition for the radioactive material if any permit is not to be renewed.

This form and new applications must be completed and returned to the EH&S Office via your DRSO, 30 days prior to the expiration date for RSC evaluation.

## 2.3 RADIOACTIVE MATERIAL USE PERMIT TERMINATION AND NON-COMPLIANCE POLICY

### USE PERMIT TERMINATION

At termination of a permit, all unused radioactive material and radioactive sealed sources must be accounted for and turned over to the EH&S Office for storage and/or disposal.

Materials may be transferred to another authorized user upon approval by Radiation Safety staff as described under TRANSFER OR SHIPMENT OF RADIOACTIVE MATERIAL.

Failure to annually renew a use permit will result in automatic cancellation of the permit. To reactivate a canceled permit, a new application must be submitted for RSC review and approval.

### NON-COMPLIANCE POLICY

The following items of non-compliance will be brought to the attention of the DRSO. The DRSO or the RSO may recommend review by the full RSC.

- Willful violation of the Institute's policies or the state regulations regarding the use of radioactive materials.
- Loss or inability to account for radioactive material.
- Repeated mid or high-level removable surface contamination ([see APPENDIX B](#)).
- Doses exceeding the Caltech administrative limits ([see section 5.1](#)).

- Improper use of radioactive materials which results in significantly endangering the safety of personnel or the environment.
- Use of radioactive materials not authorized by the permit.

Depending on the severity of the incident, the RSC will take appropriate action up to revocation of the permit.

# CHAPTER 3 - PROCUREMENT AND TRANSFER OF RADIOACTIVE MATERIALS

## 3.1 ORDERING AND RECEIPT

Radioactive material may be brought onto campus only with the prior approval of the Radiation Safety staff.

All incoming radioactive material must be covered by a valid permit. The steps for obtaining radioactive material are outlined below.

### ORDERING

All radioactive material coming to the 1201 E. California Boulevard campus should be addressed:

Radiation Safety Office  
Attn: {user's name}  
1201 E. California Boulevard  
Pasadena, CA 91125

Exception: With prior approval of Radiation Safety staff, large, heavily shielded orders may be delivered directly to the purchaser but must be opened under the supervision of Radiation Safety staff.

### SINGLE PURCHASE

- Complete a purchase requisition, indicating material is radioactive, and send it to the RSO.
- Radiation Safety staff will verify that the material is covered by a valid permit and forward the purchase requisition to Procurement Services.
- Procurement Services processes the order only after approval from Radiation Safety staff.
- Orders can also be placed through TechMart.

### STANDING PURCHASE ORDERS

Divisions may establish standing purchase orders with vendors with the approval of Radiation Safety staff. Follow division procedures to place an order and call the EH&S Office and provide the following information:

Company  
Principal Investigator  
Permit number  
User  
Location for delivery  
Nuclide, Activity, and Form

Radiation Safety staff will verify the order is covered by a valid permit.

### NON-PURCHASED MATERIAL (from other researchers, free samples from vendors, etc.)

Verify with the sender that material will be shipped to the RSO. Call EH&S and provide the following information:

Sender  
Principal Investigator/ User  
Permit number  
Location for delivery  
Nuclide, Activity, and Form

Radiation Safety staff will verify the order is covered by a valid permit.

Note: If radioactive material is to be hand carried onto campus, it must first be brought to the EH&S Office.

## **RECEIPT**

When radioactive material is received in the EH&S Office, the following actions are taken:

- Containers are checked for damage or contamination.
- A check is made to ensure the order was called in (as required when ordering) and that the material is covered by a valid permit. Material not covered by a valid permit will not be released until a new permit is issued or a current permit is amended.
- An entry is made in the inventory database file.
- Material is delivered to the user.
  - Material is generally delivered once per day in the afternoon. If there are special time requirements, arrangements can be made to pick up the material from the EH&S Office.

Note: If an order was not called in, a delay in delivery may result. This delay can occur for a variety of reasons. For example, the user's name may be spelled incorrectly or not appear on the packing slip, or there may be users in different groups with the same name.

## **OFF-CAMPUS FACILITIES**

Authorization must be obtained from Radiation Safety staff before radioactive material is shipped directly to an off-campus facility. Qualified individuals will be designated by Radiation Safety staff to receive radioactive material shipments at the facility.

## **3.2 TRANSFER OR SHIPMENT OF RADIOACTIVE MATERIAL**

Radioactive material may only be shipped from the campus or transferred to another group with the prior approval of Radiation Safety staff.

### **TRANSFER TO ANOTHER CALTECH PERMIT**

The group in possession of the material must obtain approval from Radiation Safety staff prior to transfer.

Radiation Safety staff will verify material is covered by a valid permit issued to the receiving group and authorize transfer.

An entry is made in the inventory database file.

### **SHIPMENT OFF CAMPUS**

Contact the EH&S Office to arrange shipment. Radiation Safety staff will verify that the organization to receive the material is properly licensed.

Radiation Safety staff will prepare or inspect the shipping container, prepare shipping documents, and ensure the package is properly labeled.

# CHAPTER 4 - POLICIES AND PROCEDURES FOR RADIONUCLIDE USE IN THE LABORATORY

## A. POSTING AND MARKING OF AREAS AND EQUIPMENT

### ENTRANCE

Each laboratory or area where radioactive materials are used or stored must be posted at the entrance with a **CAUTION RADIOACTIVE MATERIAL** sign. The sign must include the name and after-hours phone number of the PI or designee. Entry warning signs are to be posted and removed only by Radiation Safety staff.



**CAUTION  
RADIOACTIVE MATERIAL**

### RADIATION AREA

Areas where radiation levels might expose a person to 5 millirem in any one hour must be posted with a **CAUTION RADIATION AREA** sign. Equipment doors and covers need not be posted if radiation levels are high only when doors are open.

### RADIOACTIVE MATERIAL WORK AREAS

Areas used for work with unsealed radioactive materials must be clearly marked with **CAUTION RADIOACTIVE MATERIAL** tape.

### STORAGE AREAS AND CONTAINERS

Refrigerators, freezers, and other "in lab" storage areas and containers in which radioactive materials are stored or transported must have a visible **CAUTION RADIOACTIVE MATERIAL** label. Labels should be removed from containers that are empty and not contaminated.

### EQUIPMENT

Laboratory equipment (flasks, beakers, centrifuges, etc.) containing radioactive materials should be marked with **CAUTION RADIOACTIVE MATERIAL** tape.

### CONTAMINATED AREAS AND EQUIPMENT

Radiation Safety staff may mark areas and equipment to indicate significant levels of contamination found during surveys. These markings are to be removed only after the article or area has been decontaminated.

### OTHER

Radiation Safety staff may specify additional postings to control access or ensure safe operations.

## 4.1 LABORATORY SAFETY PRACTICES

Each permit lists the type of workplace and protective equipment required for the use of radionuclides. Note: See [APPENDIX C, WORKPLACE STANDARDS FOR OPERATIONS WITH UNSEALED RADIOACTIVE MATERIALS](#) for more information. In addition to the workplace requirements in APPENDIX C, the

following are always applicable:

## CLOTHING

A lab coat or apron, disposable gloves, and appropriate eye protection should always be worn whenever unsealed sources of radioactive material are handled (even in tracer amounts).

## PIPETTING

Pipetting solutions by mouth is extremely dangerous and must not be done under any circumstances.

## FOOD

Do not smoke, eat, store food, or apply cosmetics in any laboratory where unsealed radioactive materials are used or stored, except in designated "clean areas."

Clean areas may be established in laboratories or rooms where radioactive materials are stored or used if:

1. their boundaries are clearly delineated,
2. they are labeled to exclude the use or storage of radioactive materials, and
3. they are not in areas where there is any possibility of airborne radioactivity.

## SECONDARY CONTAINERS

To avoid spills, use metal or plastic outer trays or beakers to carry liquid radioactive materials.

## OPEN WOUNDS

Do not work with unsealed radioactive materials with open cuts, sores, etc. on exposed skin areas, even if bandaged.

## WASHING

After handling radioactive materials, be sure to wash your hands thoroughly before handling food, tobacco, etc.

## SHIELDING OF RADIOACTIVE MATERIALS

When not in use, radioactive sources and stock solutions in the laboratory shall be stored or shielded so that radiation levels in occupied areas will not expose persons unnecessarily.

RADIATION	SHIELDING
Low and intermediate energy beta (H-3, C-14, S-35)	These do not usually present an external radiation hazard and do not require shielding.
High energy beta (P-32, Sr-90)	These should be shielded first with at least ¼" thick Lucite. *
Gamma (I-125, Cr-51)	These should be shielded with lead.

\* Lead can then be used, if necessary, to shield any bremsstrahlung x-rays produced in Lucite.

## AEROSOLS, DUSTS, AND GASES

Procedures involving aerosols, dusts, volatile or respirable material must be conducted in hoods or suitable closed systems approved by Radiation Safety staff. Where practical, suitable traps should be

used to minimize environmental releases.

## 4.2 GUIDELINES FOR LABORATORY SURVEYS

### SURVEY OF WORK AREAS

Users of radioactive materials are required to survey their work areas (hoods, bench tops, sinks, floors, etc.) after each experiment and at any time there is a reason to suspect a spill or contamination incident. Radiation Safety staff surveys all laboratories on a regular basis.

Under certain conditions, laboratories are required to keep written documentation of contamination surveys.

Required surveys are listed in the table below.

Type of Survey	Frequency	Performed by	Documented
Routine Survey	After each experiment and at any time there is reason to suspect a spill or contamination incident	User	No
Internal Survey	Weekly in laboratories where activities of at least 10 mCi (or 1 mCi NaI) are handled, or in laboratories where two consecutive Radiation Safety staff surveys have found high level contamination. *	Laboratory Personnel	Yes - in laboratory
Radiation Safety Survey	Monthly or bi-monthly	Radiation Safety staff	Yes - in EH&S Office

\* Internal surveys will be required until the laboratory has had four consecutive Radiation Safety staff surveys with no high-level contamination found.

### SURVEY METERS

PI's must provide radiation survey meters or appropriate counting instruments for use in laboratories where radioactive materials are used.

### RECOMMENDED INSTRUMENTS

RADIATION	INSTRUMENT
Low energy beta (H-3)	Liquid scintillation counter for wipe surveys
Intermediate energy beta (S-35, C-14, P-33)	G-M survey meter with a thin window (~2mg/cm <sup>2</sup> ) detector; Liquid scintillation counter for wipe surveys
High energy beta (P-32, Sr-90)	G-M survey meter with a thin window detector
Low energy gamma (I-25)	Survey meter with a thin NaI crystal scintillation detector; Liquid scintillation counter or gamma counter for wipe surveys
High energy gamma (Cr-51, Co-60)	G-M survey meter or ion chamber survey meter

## **MAINTENANCE**

Radiation Safety staff will calibrate survey meters, check for proper operation, and replace weak or defective batteries at least annually.

It is the PI's responsibility to make the meters available and to obtain any other servicing or repairs necessary to keep the meters operational.

## **4.3 CONTROL OF RADIOACTIVE MATERIAL**

### **RADIOACTIVE MATERIALS CONTROLS**

PI's and users must ensure that radioactive materials and sources are used only as described on the applicable permit. Materials must not be loaned or transferred to persons not named on the permit without the prior approval of Radiation Safety staff. (See [TRANSFER OR SHIPMENT OF RADIOACTIVE MATERIAL](#).)

### **LOSS OR DAMAGE**

The loss, disappearance, or damage of radioactive materials or radiation sources must be reported to Radiation Safety staff *immediately* upon discovery. Radiation Safety staff will determine if the quantity involved requires notification of the RHB.

### **INVENTORY**

Radiation Safety staff maintain the campus inventory record of all incoming and outgoing shipments of radioactive materials, including waste.

### **ANNUAL REPORT BY PRINCIPAL INVESTIGATOR**

Each PI is required to report annually, at application renewal time, the amount of material on hand for each permit.

## **4.4 RADIOACTIVE WASTE DISPOSAL PROCEDURES**

Radioactive waste may only be disposed of by calling the EH&S Office for pick up or by placing a work request through the Facilities Service Request portal. No radioactive waste is to be disposed of in ordinary trash receptacles. No liquid waste may be disposed of in drains or other sewer openings by laboratory personnel.

### **MIXED HAZARDOUS / RADIOACTIVE WASTE**

Radioactive waste containing any hazardous chemicals requires special handling. Radiation Safety staff must be consulted *before* any such waste is generated.

### **STORAGE OF RADIOACTIVE WASTE**

The RSC has approved the storage of radioactive waste by EH&S Office. The purpose of this storage is to allow time for the decay of waste containing short-lived radionuclides and to facilitate the proper disposal of all radioactive waste.

Therefore, it is very important to place radioactive waste in the appropriate container. Containers will be designated for radionuclides with half-lives less than 15 days (P-32), between 15 and 90 days (S-35, I-125, Cr-51), and greater than 90 days (H-3, C-14).

## **RADIOACTIVE WASTE PICK-UP REQUEST**

When the waste container is nearly full, phone the EH&S Office for pick up or by completing a work request through the Facilities Service Request portal and supply the following information:

Principal Investigator  
Location of container  
Number on tag attached to container.

Radiation Safety staff picks up waste within three working days. Note: Do not wait until the container is packed full to request a pick-up.

## **SOLID WASTE**

Place solid waste in containers supplied by Radiation Safety staff. Be sure to use the container appropriate for the radionuclide in the waste.

Indicate PI, nuclide, and estimated activity on the tag attached to the container.

## **LIQUID WASTE**

Pour liquid waste into containers provided by Radiation Safety staff. Be sure to use the container appropriate for the radionuclide in the waste. Liquid radioactive waste includes the radioactive material and the first rinse of its experimental container.

Indicate PI, nuclide, and estimated activity on the tag attached to the container.

Note: Do not fill containers above the "fill line" indicated. Do not wait until the container is full to call in.

## **SCINTILLATION VIALS**

Filled scintillation vials must be securely capped and, in their boxes or trays. Loose vials will not be accepted.

## **ANIMAL WASTE**

Animal waste must be placed in the designated freezer approved by the Radiation Safety staff. It must be in sealed or tightly tied plastic bags and must have a tag listing the PI, nuclide, activity, and date. See [USE OF RADIOACTIVE MATERIALS IN ANIMALS](#) for more information.

## **4.5 USE OF RADIOACTIVE MATERIALS IN ANIMALS**

### **APPROVAL**

Approval to use radioactive materials in animals requires authorization from both the Institute Animal Care and Use Committee (IACUC) and the RSC.

### **APPLICATION FOR USE**

Submit the application to the EH&S Office with a copy of the approved protocol from the IACUC.

### **SPECIAL REQUIREMENTS**

Adequate animal care facilities must be used, and provisions must be made for the collection and storage of animal carcasses and associated waste.

- Wear lab coats and gloves.
- Practice contamination control when injecting animals with radioactivity.
- Label all cages with warning signs indicating use of radioactive materials.
- All radioactive waste, including excreta, must be discarded in radioactive waste containers as

described below.

- The animal housing facility and cages must be routinely surveyed. Areas containing removable contamination must be immediately decontaminated.
- Practice contamination control and containment. Separate cages containing radioactive materials from cages not containing radioactive materials.
- Decontaminate cages before releasing them to general use.

## **ANIMAL WASTE**

Animal excreta should be regarded as radioactive unless appropriate monitoring indicates that it is not. Excreta must be double-bagged and labeled with the name of the PI, the date and isotope. Then placed in a freezer designated by the Radiation Safety staff.

- Animal carcasses must be double-bagged and labeled with the name of the PI, the date, the isotope, and quantity administered. Then placed in a freezer designated by the Radiation Safety staff.
- Sharps contaminated with radioactive materials must be appropriately stored in a sharps container.

## **TRAINING OF CARETAKERS AND CUSTODIANS**

PI's are responsible for ensuring that animal caretakers and custodians are adequately trained and supervised in the observance of necessary precautions, and are aware of potential hazards. The EH&S Office will provide additional assistance as needed with the training of animal care personnel and the monitoring of the facility.

# CHAPTER 5 - RADIATION DOSE STANDARDS AND PERSONNEL MONITORING

## 5.1 RADIATION DOSE STANDARDS

### DOSE STANDARDS

Permissible occupational radiation dose levels are set by the California Radiation Control Regulations (CRCR). The levels are based on recommendations by the International Committee on Radiation Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and by federal and state regulatory agencies.

The CRCR limits for adult radiation workers are listed in the table below.

Dose Category	Adult Occupational Dose Limit
Total Effective Dose Equivalent (TEDE)	5 rem/year
Total Organ Dose Equivalent (TODE)	50 rem/year to any individual organ or tissue except the lens of the eye
Eye Dose Equivalent	15 rem/year
Shallow Dose Equivalent	50 rem/year to the skin or any extremity

### CALTECH ADMINISTRATIVE LIMIT

The Caltech RSC has established the general policy that planned radiation doses shall not exceed ten percent (10%) of the above limits.

It should be noted that the above dose limits are permissible *occupational* dose limits. These dose limits are in addition to the background radiation dose or medical radiation dose received by the worker. The U.S. average annual background radiation due to natural sources is approximately 300 millirem/yr.

### MINORS

Radiation dose limits for radiation workers under the age of 18 are 10 percent of those listed above for adult workers.

### MEMBERS OF PUBLIC

The total effective dose equivalent to members of the public is limited to 0.1 rem in a year and the dose in any unrestricted area from external sources can not exceed 0.002 rem in any one hour.

### PREGNANCY

The dose limit to the embryo/fetus of a declared pregnant woman is 0.5 rem. Efforts must also be made to avoid a dose substantially higher than 0.06 rem in one month. A declared pregnant woman means a woman who has voluntarily informed the EH&S Office, in writing, of her pregnancy and the estimated date of conception.

The dose to an embryo/fetus is the sum of the deep-dose equivalent to the declared pregnant woman and the dose from internally deposited radionuclides in the embryo/fetus and in the woman.

## ALARA GUIDELINE

In practice, radiation doses should be *As Low As is Reasonably Achievable*. ALARA is a guideline meant to strike a balance between the cost of radiation protection and the health benefit derived from that protection.

It is the responsibility of everyone including radiation workers, principal investigators, radiation safety personnel and the administration to operate within the ALARA guideline. This is achievable by outlining safety procedures for radiation environments and by monitoring the workplace environment to control contamination and minimize doses.

## 5.2 PERSONNEL MONITORING (EXTERNAL)

### CRITERIA

The CRCR requires that anyone who is likely to receive a dose in excess of 10 percent of the maximum permissible occupational dose in any year must be monitored for exposure to radiation.

Although experience has shown that no one at Caltech falls into this category and Caltech's policy is that planned doses will be less than ten percent of the regulatory limits for adults, the RSC has determined that personnel dosimeters are to be worn by anyone in the following categories:

- Persons using 1 mCi or more of a radionuclide with a beta energy of greater than 600 keV or with a gamma ray of any energy.
- Persons entering a posted High Radiation Area (>100 mrem/hr).

The Radiation Safety staff will determine when anyone else should be issued a dosimeter.

### EXTERNAL MONITORING

Generally, thermoluminescent dosimeters (TLDs) are used for monitoring dose to the whole body and extremities. These monitoring devices are exchanged either monthly or quarterly.

Radiation Safety staff may require special dosimeters such as ion chambers be used in High Radiation Areas (>100 mrem/hr), certain areas be posted with environmental dosimeters or alarmed electronic dosimeters be installed and used under certain conditions.

DEVICE	ASSIGNED TO	EXCHANGE SCHEDULE
1. Whole Body Dosimeter	Persons using 1mCi or more of a radionuclide with a beta energy of greater than 600 keV or with a gamma ray of any energy.	Exchanged at the beginning of each month or quarter, as appropriate.
2. Extremity Dosimeter		
3. Environment Dosimeter	Area	

### DOSE HISTORY

Radiation workers interested in reviewing their dosimetry records should contact the EH&S Office. A request in writing is required for anyone interested in obtaining a copy of their dosimetry records.

## MONITORING

Dosimeters are processed commercially, and dose reports are generated. These reports are reviewed by the Radiation Safety staff. Any unusual or excessive doses are investigated by the Radiation Safety staff and, when appropriate, preventive measures are implemented.

## PRECAUTIONS

The whole-body dosimeter is to be worn when in a laboratory or area in which radioactive materials are used. The extremity dosimeter ring is to be worn when handling radioactive materials. Both dosimeters register radiation from gamma rays, x-rays and high energy beta particles. Neither dosimeter detects radiation from low energy beta emitters such as H-3, C-14 and S-35. In the case of neutron radiation, special dosimeters are issued.

The whole-body dosimeter should be worn at the collar or chest level to measure the radiation dose received by the trunk of the body.

The extremity dosimeter is worn under gloves on a finger of the hand expected to receive the larger radiation dose. The label of the extremity dosimeter should be on the palm side of the hand.

The radiation dose recorded by the dosimeters is your occupational dose record. Make sure that this record is valid and accurate by observing the following precautions:

- Do not wear anyone else's dosimeter.
- When not in use, the dosimeters should be left in a place free from radiation, moisture, and high temperatures.
- Do not deliberately expose the dosimeter to radiation.
- Do not tamper with the dosimeter packet.
- If you have reason to believe that a dosimeter has been damaged, lost, or exposed or contaminated accidentally, notify the EH&S Office as soon as possible so a replacement can be issued.

## DOSIMETER EXCHANGE

It is the responsibility of individuals to ensure that their dosimeters are exchanged monthly or quarterly, as appropriate. In the case of a dosimeter which has been damaged, lost, exposed or contaminated accidentally, the Radiation Safety staff will investigate and make a dose estimate for the period in question.

## 5.3 BIOASSAY GUIDELINES

### INTRODUCTION

When using radioactive materials, accidental uptake may occur. This can happen as the result of loose surface contamination or as the result of volatile chemical forms of radionuclides. The second event is of special concern when individuals are working with I-125 or I-131.

For example, radioiodinated solutions and compounds undergo decomposition that may result in the volatilization of radioiodine. If this happens, accidental uptake of radioiodine may occur. In the body, iodine concentrates in the thyroid and irradiates that organ.

The bioassay program is designed to enable the Radiation Safety staff to determine the amount of

radioactivity in the body and to calculate the radiation dose. Any unusual or excessive doses are investigated by the Radiation Safety staff and, when appropriate, preventive measures are implemented.

## PROGRAM PARTICIPATION

Caltech's license requires that any individual or group receiving unsealed sources in amounts exceeding the levels described below be included in the bioassay program.

ISOTOPE	ACTIVITY	FORM
I-125 or I-131	10 mCi	NaI (Volatile)
	100 mCi	Protein Bound (Non-volatile)
P-32 or S-35	100 mCi	Any
H-3	100 mCi	Organic
	1000 mCi	Inorganic
Other	As determined by the RSO	

## USE OF I-125 OR I-131

FREQUENCY OF THYROID SCAN		
TYPE OF BIOASSAY	NECESSARY WHEN...	DONE...
Baseline	beginning work with I-125 or I-131 in quantities stated above.	before beginning work with radioiodine.
Routine	working with quantities stated above (at any one time or cumulatively over a one-month period).	within 7 days for I-125 or 3 days for I-131.
Special	determining internal uptake after an incident involving radioiodine.	as determined by the RSO.
Diagnostic	monitoring existing internal contamination.	as determined by the RSO.

## USE OF OTHER RADIONUCLIDES

FREQUENCY OF URINALYSIS		
TYPE OF BIOASSAY	NECESSARY WHEN...	DONE...
Routine	working with quantities stated above (at any one time or cumulatively over a one-month period).	within 7 days.
Special	determining internal uptake after an incident involving radioactive material.	as determined by the RSO.
Diagnostic	monitoring existing internal contamination.	as determined by the RSO.

# CHAPTER 6 - EMERGENCY PROCEDURES

## INTRODUCTION

During the course of routine operations, radioactive material may be spilled resulting in contamination of personnel or lab equipment and areas. Correct action taken during such an incident can prevent unnecessary doses to personnel and further spread of contamination. ([See APPENDIX C: CONTAMINATION LEVELS AND DECONTAMINATION REQUIREMENTS.](#))

## GENERAL PROCEDURES

Medical attention takes precedence over radiological or other concerns in the case of a serious injury. Inform medical personnel if there is the possibility of contamination.

Do not risk external or internal dose to save equipment or an experiment. An exception to this should only be made in the direction of a person qualified to evaluate the hazards involved.

Take all reasonable precautions to limit the spread of radioactive contamination.

- Limit access to the area.
- Turn off the ventilation system, if possible.
- Prevent the spread of liquid or powdered contaminants.

## SERIOUS INJURY INVOLVING RADIOACTIVE MATERIAL

1. Dial extension x5000 or call 626-395-6727 and request paramedics.
2. Tell the operator that it is also a radiation emergency and have them notify the RSO or the alternate.
3. When paramedics arrive, inform them of the possibility of radioactive contamination.
4. Determine and record the radionuclide, the activity involved, and the chemical form.
5. Follow steps for a major or minor spill as appropriate.

## MAJOR SPILL

A spill is considered major if it results in any of the following:

- Internal radiation dose to personnel (inhalation/ingestion of radioactive material).
  - Excessive external radiation dose to or contamination of personnel.
  - Contamination of large areas.
  - Considerable delay in work.
1. Notify personnel not involved in the spill to vacate the laboratory.
  2. Prevent other personnel from entering the contaminated area.
  3. Monitor personnel for contamination.
  4. Remove contaminated clothing. If skin is contaminated, flush thoroughly with water and wash with mild soap.
  5. Confine movement of all potentially contaminated personnel to prevent further spread of contamination.
  6. Cover a liquid spill with absorbent paper or pads. Dampen dry powders, being careful not to spread contamination. Use oil if the material is water reactive. Do not attempt to clean

- up the spill.
7. Notify the EH&S Office (x6727 or 626-395-6727). If after working hours, dial x5000 or 626-395-5000 and instruct the operator to contact the RSO or the alternate. Also notify the laboratory supervisor or PI.
  8. If possible, turn off fans and ventilation that might spread vapors or dust.
  9. Determine and record the radionuclide and activity involved, the chemical form, and personnel involved.
  10. Assist Radiation Safety staff in evaluation and decontamination.

## **MINOR SPILL**

A spill can generally be considered minor if it contaminates small areas or equipment and results in:

- No external or internal contamination of personnel.
  - No excessive external radiation dose to personnel.
  - No serious delay in work.
1. Notify personnel in the area that a spill has occurred.
  2. Monitor personnel leaving the area and remove any contaminated clothing.
  3. Cover a liquid spill with absorbent paper or pads.
  4. Dampen dry powders, being careful not to spread contamination. Use oil if the material is water reactive.
  5. Call the EH&S Office (x6727 or 626-395-6727) if assistance is needed.
  6. Plan the decontamination procedure before proceeding. Keep in mind these points:
    - Limit personnel to a minimum.
    - Wear appropriate protective clothing.
    - Dispose of all contaminated material as radioactive waste.
    - Use appropriate survey instruments.
    - Perform wipe tests if necessary.
    - After decontamination, check all areas around the spill and all personnel for contamination. Be sure to check your hands and shoes.

## APPENDIX A: CLASSIFICATION OF UNSEALED RADIONUCLIDES ACCORDING TO RELATIVE HAZARD POTENTIAL

HAZARD POTENTIAL	RADIONUCLIDE
<b>VERY HIGH (HAZARD CLASS I)</b>	Sr-90, Pb-210, Po-210, At-211, Ra-226, Ac-227, Th-228, Th-229, Th-230, Th-231, U-233, Pu-238, Pu-239, Am-241, Cm-242, Cf-252, other transuranic nuclides
<b>HIGH (HAZARD CLASS II)</b>	Ca-47, Fe-59, Co-60, Sr-85, Sr-89, Y-91, Ru-106, Cd-109, Cd-115, I-125, I-131, Ba-140, Ce-144, Sm-151, Eu-152, Eu-154, Tm-170, Hg-203, Bi-207, Th-232, natural thorium, natural uranium.
<b>MODERATE (HAZARD CLASS III)</b>	Na-22, Na-24, P-32, P-33, S-35, Cl-36, K-42, Ca-45, Sc-46, Sc-47, Sc-48, V-48, Mn-56, Fe-55, Co-57, Co-58, Ni-59, Ni-63, Cu-64, Cu-67, Zn-65, Ga-67, Ga-68, Ga-72, As-74, As-76, Br-82, Kr-85, Rb-84, Rb-86, Y-90, Zr-95, Nb-95, Mo-99, Tc-99, Rh-105, Pd-103, Ag-105, Ag-111, Sn-113, Te-127, Te-129, I-132, Xe-133, Cs-137, La-140, Pr-143, Pm-147, Ho-166, Lu-177, Ta-182, W-181, Re-183, Ir-190, Ir-192, Pt-191, Pt-193, Au-196, Au-198, Au-199, Tl-200, Tl-202, Tl-204, Pb-203, Hg-197
<b>LOW (HAZARD CLASS IV)</b>	H-3, Be-7, C-14, F-18, Cr-51, Ge-68, Ge-71, Sr-87m, Tc-99m, In-111, Tl-201

The hazard potential of a radionuclide is considered during the evaluation of an application. It is used when determining the workplace type and other approval conditions.

These classifications are based on various published data, Caltech experience, and the judgment of the RSO.

## APPENDIX B: CONTAMINATION LEVELS AND DECONTAMINATION REQUIREMENTS

Type of Contamination	Contamination Levels (pCi/100cm <sup>2</sup> )*		
	Low	Mid	High
Alpha	5 - 10	10 - 100	> 100
Gamma or High Energy Beta	100 - 250	250 – 1,000	> 1,000
Low or Intermediate Energy Beta	1,000 – 2,500	2,500 – 10,000	> 10,000
<b>Decontamination Requirements</b>	Should be decontaminated promptly, but may be tolerated in a particular work situation (Must be in a clearly marked radioactive work area)	Must be decontaminated promptly. A Notice of Unsatisfactory Condition will be sent to the PI if decontamination is not completed within one week.	Requires immediate action. A Notice of Unsatisfactory Condition will be sent to the PI. Depending on the extent of the contamination, further use may be suspended until decontamination is completed. The PI may be required to report to the RSC stating the reason for the incident and actions taken to minimize the risk of a repeat.

\*Levels for Type D laboratories are ten times those shown.

The degree of hazard involved with radioactive contamination is dependent on a number of factors such as total area, radionuclide, chemical/physical form, accessibility to the area, and surface permeability.

Radiation Safety staff are available to assess hazards and to provide guidance and assistance in decontamination.

## APPENDIX C: WORKPLACE STANDARDS FOR OPERATIONS WITH UNSEALED RADIOACTIVE MATERIAL

The RSC (or sub-committee) will specify the minimum required workplace type as one of the approval conditions for each radioactive material use permit. The RSC takes into account the nature of the operation, the radionuclide involved, the physical and chemical form of the radionuclide, the activity to be used, and other possible hazards. Below are the minimum requirements for each workplace type.

### TYPE A - Laboratory

1. Must have a ventilation system that provides at least four air changes per hour.
2. Must have smooth and impermeable work surfaces for experiments involving radioactive material.

### TYPE B - Laboratory with Fume Hood

1. Must satisfy Type A requirements.
2. Must be equipped with a fume hood. The hood must have an average face velocity of at least 100 feet per minute with the sash at a workable height.

### TYPE C - Restricted Use Laboratory

1. Must satisfy Type B requirements.
2. Must be used primarily for radioactive material work. No area of the laboratory may be used as a study area.

### TYPE D - High Level Laboratory \*

1. Must satisfy Type C requirements.
2. Additional requirements will be determined by the RSC on a case-by-case basis. These requirements may include some or all OF the following:
  - a. Glove boxes
  - b. High efficiency filtration of exhaust air
  - c. Contamination control at exit points
  - d. Remote handling facilities
  - e. High level waste collection facilities
  - f. Alarm systems to signal high levels of airborne radioactivity or high radiation fields.

\*The only laboratory that can be upgraded to a Type D laboratory is the Isotope Handling Lab.