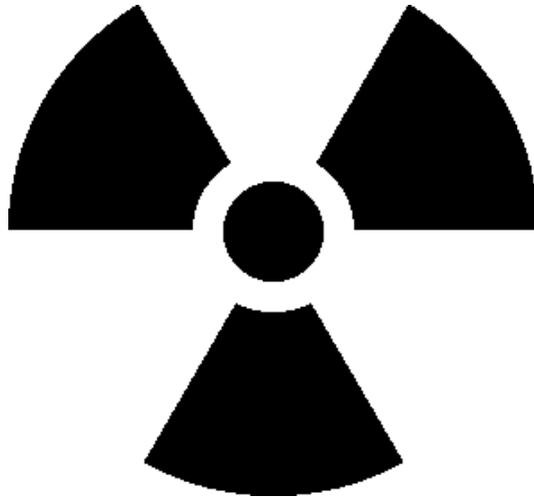


CALIFORNIA INSTITUTE OF TECHNOLOGY



RADIATION SAFETY MANUAL

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CALTECH RADIATION SAFETY MANUAL

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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 Health Services. 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 you need to use radioactive material in accordance with Caltech policies and California regulations. Copies of the license and the California Radiation Control Regulations are available for review and inspection at the Safety Office.

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

RADIATION-PRODUCING MACHINE REGULATIONS

Radiation-producing machines are registered in accordance with the California Radiation Control Regulations. The Radiation Safety Committee approves use of radiation-producing devices. For more detail, see *X-ray Safety Manual*.

1.2 RADIATION SAFETY COMMITTEE

PURPOSE

The Radiation Safety Committee 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 use and possession 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 a biennial review of the radiation protection program to determine that all activities are being conducted safely and in accordance with California Radiation Control Regulations and the Institute's license.

Advising and keeping current the President and Administrative Officers on matters involving the use of radioactive material and radiation-producing machines.

MEETINGS

The Committee meets once every calendar quarter.

MEMBERSHIP

Radiation Safety Committee members include:

Faculty members (appointed Division Radiation Safety Officers) with expertise in the use of radioactive material or use of radiation-producing devices.

The Radiation Safety Officer who also serves as the Executive Officer.

The Director of Environment Health and Safety, a representative of administration.

Other members shall be appointed at the discretion of the President.

SUB-COMMITTEE

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

Except for those uses requiring full committee approval (see RADIOACTIVE MATERIAL USE APPROVAL), the DRSO and the Radiation Safety Officer 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 Radiation Safety Committee are directed to the Associate Vice President for Campus Planning and the President as appropriate.

1.3 RADIATION SAFETY OFFICER AND STAFF

RADIATION SAFETY OFFICER The Radiation Safety Officer (RSO) is appointed by the Director of Physical Plant. In addition to responsibilities as a committee member, the RSO directs the Radiation Safety Program.

RADIATION SAFETY STAFF Under the direction of the RSO, the staff of the Safety Office:

Assists in developing general policies for control of radiation.

Conducts training in the safe use of radioactive materials and radiation-producing machines.

Evaluates equipment and facilities, including the testing of containment systems such as fume hoods and glove boxes.

Evaluates operational techniques and procedures.

Conducts surveys for contamination control in laboratory areas where unsealed radioactive materials are handled.

Performs environmental monitoring of areas involving use of radioactivity or radiation.

Responds to emergencies and investigates accidental doses.

Provides advice on decontamination following spills or prior to modification of facilities or equipment.

Issues personnel dosimetry devices.

Performs bioassay analysis for internal deposition of radioactivity.

Tests sealed radioactive sources for leakage.

Receives and inspects packages containing radioactive material.

Prepares outgoing shipments of radioactive materials in accordance with current federal and state regulations.

Picks up radioactive waste.

Calibrates portable radiation survey instruments.

Maintains records.

Aids in completing the application for a permit to use radioactivity and furnishes consulting services.

2. AUTHORIZATION TO USE RADIOACTIVE MATERIAL

2.1 APPLICATION FOR POSSESSION AND USE

APPLICATION

Faculty members who wish to acquire and use radioactive materials must submit an *Application for Possession and Use of Radioactive Materials* form to the Radiation Safety Committee (RSC) via the Division Radiation Safety Officer (DRSO). A personal statement of training and experience for use of radioactive material must accompany the application form for a new Principal Investigator (PI).

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

Applications must include the name of the Principal Investigator, 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 for completing them are available from the Safety 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 Safety Office. 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 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 SUB-COMMITTEE

The Radiation Safety Committee has designated the Radiation Safety Officer (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 Committee.

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 Committee 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 Safety 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 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 Safety 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 must be accounted for and turned over to the Safety Office for storage and disposal.

Materials may be transferred to another authorized user upon approval by Radiation Safety 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 Committee 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-committee.

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 C).

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 Committee will take appropriate action up to revocation of the permit.

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 Radiation Safety.

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, large, heavily shielded orders may be delivered directly to the purchaser, but must be opened under the supervision of Radiation Safety personnel.

SINGLE PURCHASE

Complete a purchase requisition, indicating material is radioactive, and send to the Radiation Safety Office.

Radiation Safety will verify that the material is covered by a valid permit and forward the purchase requisition to the purchasing department.

Purchasing processes the order only after approval from Radiation Safety.

OPEN ORDERS

Divisions may establish open purchase orders with vendors with the approval of Radiation Safety.

Follow division procedures to place an order.

Call Radiation Safety and provide the following information:

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

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

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

Verify with sender that material will be shipped to the Radiation Safety Office.

Call Radiation Safety and provide the following information:

- Sender
- Principal Investigator
- Permit number
- User
- Location for delivery
- Nuclide
- Activity
- Form

Radiation Safety will verify 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 Radiation Safety Office.

RECEIPT

When radioactive material is received in the Radiation Safety 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 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 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 Radiation Safety Office.

Note: If 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 before radioactive material is shipped directly to an off-campus facility. Qualified individuals will be designated by Radiation Safety 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.

TRANSFER TO ANOTHER CALTECH PERMIT

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

Radiation Safety 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 Radiation Safety to arrange shipment.

Radiation Safety will verify that the organization to receive the material is properly licensed.

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

4. POLICIES AND PROCEDURES FOR RADIONUCLIDE USE IN THE LABORATORY

4.1 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 <i>CAUTION RADIOACTIVE MATERIAL</i> sign. The sign must include the name and after-hours phone number of the Principal Investigator or designee. Entry warning signs are to be posted and removed only by Radiation Safety.
RADIATION AREA	Areas where radiation levels might expose a person to 5 millirem in any one hour must be posted with a <i>CAUTION RADIATION AREA</i> 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 <i>CAUTION RADIOACTIVE MATERIAL</i> 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 <i>CAUTION RADIOACTIVE MATERIAL</i> 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 <i>CAUTION RADIOACTIVE MATERIAL</i> tape.
CONTAMINATED AREAS AND EQUIPMENT	Radiation Safety 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 may specify additional postings to control access or ensure safe operations.

4.2 LABORATORY SAFETY PRACTICES

Each permit lists the type of workplace and protective equipment required for use of radionuclides.

Note: See APPENDIX B, WORKPLACE STANDARDS FOR OPERATIONS WITH UNSEALED RADIOACTIVE MATERIALS for more information.

In addition to the workplace requirements in APPENDIX B, 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 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 the lucite.

AEROSOLS, DUSTS, AND GASES

Procedures involving aerosols, dusts, volatile or respirable material must be conducted in hoods or suitable closed systems approved by Safety. Where practical, suitable traps should be used to minimize environmental releases.

4.3 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 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 surveys have found high level contamination.*	Laboratory personnel	Yes - in laboratory
Radiation Safety survey	Monthly or bi-monthly	Radiation Safety personnel	Yes - in Safety Office

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

SURVEY METERS

Principal Investigators 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 ²) 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-125)	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

MAINTENANCE

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

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

4.4 CONTROL OF RADIOACTIVE MATERIAL

RADIOACTIVE MATERIALS CONTROLS

Principal Investigators 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. (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 *immediately* upon discovery. Radiation Safety will determine if the quantity involved requires notification of the state.

INVENTORY

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

ANNUAL REPORT BY PRINCIPAL INVESTIGATOR

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

4.5 RADIOACTIVE WASTE DISPOSAL PROCEDURES

Radioactive waste may only be disposed of by calling Radiation Safety for pick up. 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 must be consulted *before* any such waste is generated.

STORAGE OF RADIOACTIVE WASTE

The Radiation Safety Committee has approved the storage by Radiation Safety of radioactive waste. 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.

It is very important, therefore, 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).

SOLID WASTE

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

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

When container is nearly full, call Radiation Safety for pick up and supply the following information:

Principal Investigator
Location of container
Number on tag attached to container

Radiation Safety picks up waste within three working days.

Note: Do not wait until can is packed full to call in.

LIQUID WASTE

Pour liquid waste into containers provided by Radiation Safety. 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 Principal Investigator, nuclide, and estimated activity on the tag attached to the container.

When container is nearly full, call Safety for pick up and supply the following information:

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

Radiation Safety picks up waste within three working days.

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

SCINTILLATION VIALS

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

Call Radiation Safety and provide the following information:

- Principal Investigator
- Number of trays
- Location
- Nuclides and estimated activity of each

Radiation Safety picks up waste within three working days.

SCINTILLATION FLUID

Scintillation vials may be emptied into containers provided by Radiation Safety. This work should be done in an approved fume hood to prevent exposure to solvent vapors.

Completely empty and uncapped vials may be disposed of as ordinary trash, providing labels and markings which indicate the presence of radioactive materials are removed.

When container is nearly full, call Radiation Safety for pick up and supply the following information:

- Principal Investigator
- Location of container
- Nuclides and estimated activity of each

Radiation Safety picks up waste within three working days.

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

ANIMAL WASTE

Animal waste must be placed in the designated freezer in the Animal Care Facility. It must be in sealed or tightly tied plastic bags and must have a tag listing the Principal Investigator, nuclide, activity and date. See USE OF RADIOACTIVE MATERIALS IN ANIMALS for more information.

4.6 USE OF RADIOACTIVE MATERIALS IN ANIMALS

APPROVAL

Approval to use radioactive materials in animals requires authorization from both the Animal Care and Use Committee and the Radiation Safety Committee.

APPLICATION FOR USE

Submit the application to the Safety Office with a copy of the approved protocol from the Animal Care and Use Committee.

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, and placed in a freezer designated by the health physics staff.

Animal carcasses must be double-bagged and labeled with the name of the PI, the date, the isotope and quantity administered, and placed in a freezer designated by the health physics staff.

Sharps contaminated with radioactive materials must be appropriately packaged to avoid punctures.

TRAINING OF CARETAKERS AND CUSTODIANS

Principal investigators are responsible for insuring that animal caretakers and custodians are adequately trained and supervised in the observance of necessary precautions and are aware of potential hazards. The Safety Office will provide additional assistance as needed in the training of animal care personnel and the monitoring of the facility.

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 Radiation Safety Committee 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 average annual background radiation in the U.S. due to natural sources is approximately 300 millirem per year.

MINORS

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

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 Safety 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 California Radiation Control Regulations require 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 Radiation Safety Committee 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 (>100mR/hr).

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

EXTERNAL MONITORING

Generally, a film badge is used for whole body dose monitoring and a thermoluminescent dosimeter (TLD) is used for monitoring dose to the hands. These monitoring devices are exchanged either monthly or quarterly.

Radiation Safety may require special dosimeters such as ion chambers be used in High Radiation Areas (>100mR/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 1 mCi 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 Safety 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 Safety Office. Any unusual or excessive doses are investigated by the health physics staff and, when appropriate, preventive measures are implemented.

PRECAUTIONS

The whole body dosimeter you have been issued 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 Safety 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, or exposed or contaminated accidentally, the health physics 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 health physics 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 Radiation Safety Officer	

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 Radiation Safety Officer.
Diagnostic	monitoring existing internal contamination.	as determined by the Radiation Safety Officer.

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 Radiation Safety Officer.
Diagnostic	monitoring existing internal contamination.	as determined by the Radiation Safety Officer.

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.

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 at the direction of a person qualified to evaluate the hazards involved.

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

Limit access to the area.

Turn off ventilation system, if possible.

Prevent spread of liquid or powdered contaminants.

SERIOUS INJURY INVOLVING RADIOACTIVE MATERIAL

1. Dial extension 5000 and request paramedics. Tell operator that it is also a radiation emergency and have him notify the Radiation Safety Officer or his alternate. When paramedics arrive, inform them of the possibility of radioactive contamination.

2. Determine and record the radionuclide and activity involved and the chemical form.

3. 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. Prevent other personnel from entering the contaminated area.
2. Monitor personnel for contamination.
3. Remove contaminated clothing. If skin is contaminated, flush thoroughly with water and wash with mild soap.
4. Confine movement of all potentially contaminated personnel to prevent further spread of contamination.
5. Cover a liquid spill with absorbent paper or pads. Dampen dry powders, being careful not to spread contamination. Use oil if material is water reactive. Do not attempt to clean up the spill.
6. Notify Radiation Safety (x6727). If after working hours, dial x5000 and instruct operator to contact the Radiation Safety Officer or his alternate. Also notify the laboratory supervisor or Principal Investigator.
7. If possible, turn off fans or ventilation that might spread vapors or dust.
8. Determine and record the radionuclide and activity involved, the chemical form, and personnel involved.
9. Assist Radiation Safety personnel 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. Dampen dry powders, being careful not to spread contamination. Use oil if material is water reactive.
4. Call Radiation Safety (x6727) if assistance is needed.
5. 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 hands and shoes.

APPENDIX A CLASSIFICATION OF RADIONUCLIDES ACCORDING TO RELATIVE HAZARD POTENTIAL

<u>HAZARD POTENTIAL</u>	<u>RADIONUCLIDE</u>
<p>VERY HIGH (HAZARD CLASS I)</p>	<p>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</p>
<p>HIGH (HAZARD CLASS II)</p>	<p>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.</p>
<p>MODERATE (HAZARD CLASS III)</p>	<p>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</p>
<p>LOW (HAZARD CLASS IV)</p>	<p>H-3, Be-7, C-14, F-18, Cr-51, Ge-68, Ge-71, Sr-87m, Tc-99m, In-111, Tl-201</p>

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 Radiation Safety Officer.

APPENDIX B WORKPLACE STANDARDS FOR OPERATIONS WITH UNSEALED RADIOACTIVE MATERIAL

The Radiation Safety Committee (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.

*As of August, 1997, the only laboratory designated as Type D is the Isotope Handling Lab.

APPENDIX C CONTAMINATION LEVELS AND DECONTAMINATION REQUIREMENTS

Type of Contamination	Contamination Levels (pCi/100cm ²)*		
	Low	Mid	High
Alpha	5 - 10	10 - 100	> 100
Gamma or High Energy Beta	100 - 250	250 - 1000	> 1000
Low or Intermediate Energy Beta	1000 - 2500	2500 - 10000	> 10000
Decontamination Requirements	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 <i>Notice of Unsatisfactory Condition</i> will be sent to the Principal Investigator if decontamination is not completed within one week.	Requires immediate action. A <i>Notice of Unsatisfactory Condition</i> will be sent to the Principal Investigator. 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 Radiation Safety Committee 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 permeability of surface. Radiation Safety professionals are available to assess hazards and to provide guidance and assistance in decontamination.