Important Telephone Numbers

Police - Fire – Emergency………………….**911**

Campus Extension

Public Safety (campus)………………59**4-1991**
Environmental Health and Safety……59**4-6778** **(Business Hours)**

Radiation Safety……..………………59**4-6879** **(Business Hours)**
59**4-4055** **(Business Hours)**

(Business hours are Monday through Friday, 8:00 a.m. to 4:30 p.m.)

Table of Contents

Chapter 1. Introduction

The President of San Diego State University (SDSU) is responsible for maintaining a Radiation Safety Program (RSP) for the safe use of radioactive material and radiation producing machines. The Radiation Safety Manual (RSM) is a formal statement of policies and procedures as approved by the Radiation Safety Committee (RSC) and is incorporated within the radioactive materials license (RML). The purpose of this manual is to provide information and establish general uniform procedures on the proper use and handling of radioactive material and radiation producing machines. This manual has been written to afford the user as much freedom in their work as is safe and legal. If there are questions regarding its contents, the Radiation Safety (RS) Office should be consulted for further explanation or additional information.

Each Principal Investigator (PI) authorized for radiation work has been issued a copy of this manual. The manual should be used as a guide to supplement precautions for the specific work authorized on the Radiation Use Authorization (RUA). The manual should remain in the laboratory for access by all authorized users. The manual revision number will be shown on each page. Updates to the manual will be distributed by the RS Office and will be accompanied by a list of all revisions and changes to date to ensure each laboratory has the latest issue.

Chapter 2. Administration and Responsibilities

A. San Diego State University's Responsibilities

SDSU is part of the California State University (CSU) system, which is comprised of 23 campuses. Responsibility for the CSU is vested in the Board of Trustees, whose members are appointed by the Governor. The Trustees appoint the Chancellor, the chief executive officer of the system, and the Presidents, the chief executive officers on their respective campuses.

The Trustees and the Chancellor develop system-wide policy, with actual implementation at the campus level taking place through broadly based consultative procedures. The Academic Senate of the CSU, made up of elected representatives of the faculty from each campus, recommends academic policy to the Board of Trustees through the Chancellor.

It is the policy of SDSU that all necessary provisions will be made to facilitate the safe handling of radioactive material and radiation producing machines, and that all operations will be conducted in such a manner to maintain exposure As Low As Reasonably Achievable (ALARA).

SDSU's use of radioactive materials is authorized by the Radioactive Materials Broad Scope (Type A) License issued by the California Department of Public Health (CDPH). The State of California regulates the use of radioactive materials through the California Code of Regulations (CCR), Title 17, Chapter 5, Subchapter 4. All radiation workers on this campus should understand and shall adhere to these regulations.

B. The Radiation Safety Committee (RSC)

The RSC is a requirement of our Broad Scope Radioactive Materials License (RML). The RSC has the ultimate responsibility for the use of radioactive materials and radiation producing machines at SDSU and shall be the reviewing and authorizing agent for the use of all radiation on this campus. It shall set policy and establish the rules and regulations to be carried out by the RS Office. The committee has the authority to suspend or revoke any authorization for the use of radioactive materials and radiation producing machines.

C. Environmental Health and Safety (EH&S)

EH&S is responsible for the surveillance of all uses of radioisotopes and radiation producing machines and for providing consultation and radiation safety services in conformance with policies and standards set forth in this manual, governmental regulations, license conditions and federal radiation protection standards.

D. The Radiation Safety (RS) Office

The RS Office is responsible for the general administration of the Radiation Safety Program (RSP) through the authority of the RSC. The RS Office is responsible for implementing all RSC policies and procedures, and ensuring compliance with state and federal regulations. The RS office has the authority to terminate immediately any project or activity if deemed a hazard to the health and safety of the worker, campus community or other members of the public.

E. The Principal Investigator (PI)

The PI is ultimately responsible for safety in the laboratory. In addition to assuming all the responsibilities of an individual radiation worker, the PI is responsible for compliance with federal and state regulations, university policies, and his/her RUA as it pertains to use of radioactive material and radiation producing machines.

Specific responsibilities include, but are not limited to:

1. Ensuring that all personnel who have access to ionizing radiation sources under their RUA are properly instructed in the safe use of radioactive material and radiation producing machines as described in Chapter 5 of this manual.

2. Ensuring that only work authorized by their RUA is performed in approved laboratories.

3. Providing procedures for work with radioactive material and/or radiation producing machines that may be reviewed by personnel in the laboratory including emergency procedures specific to the worker's operations, and procedures for waste handling. These procedures should emphasize the principles of ALARA.

4. Maintaining accurate and current records of radioactive material inventories and having these records available for review by EH&S and regulatory agencies.

5. Ensuring that instrumentation for monitoring work areas is readily available and have current calibration stickers.

6. Ensuring that radiation hazards, storage containers and equipment are properly labeled.

7. Ordering only approved radioisotopes in quantities specified on the RUA.

8. Ensuring proper disposal of all radioactive waste as described in Chapter 8 of this manual.

9. Providing personnel protective equipment (PPE) for laboratory workers.

F. The Individual User

Any person authorized to use sources of ionizing radiation is responsible for using those sources in accordance with university policy, state and federal requirements and in a manner as to not jeopardize the health and safety of others. The individual user shall:

1. Keep exposure ALARA.

2. Wear dosimetry while performing procedures that require personnel monitoring as prescribed in this manual.

3. Maintain good housekeeping habits in the laboratory.

4. Monitor work area prior to and immediately after working with unsealed radioisotopes, including a thorough "frisk" of yourself. Any contaminated items shall remain in the laboratory.

5. Dispose of radioactive waste in accordance with university policy.

6. Report details of a spill or accident involving radioactivity immediately to the RS Office.

7. Label, segregate and secure radiation sources, equipment and waste.

8. Prevent unauthorized access to radiation sources and to laboratories where radiation sources are stored while unattended by an authorized radiation worker.

9. Not smoke, or consume food or beverages in laboratories that use radioactive material except in an area designated by the RS Office as a "Clean Area."

10. Wear all PPE as directed by the RUA.

Chapter 3. License Requirements and Administrative Control

A. General Information

SDSU possesses a Broad Scope Radioactive Materials License (RML) issued by the CDPH. The broad scope license permits SDSU to possess a wide variety of radioisotopes in varying physical and chemical forms. The license describes locations for use and sets liberal activity limits for each isotope to allow the University flexibility in current and proposed research.

The RML requires the university to have a RSC comprised of personnel who are knowledgeable in the use of radioactive materials and radiation producing machines. The committee develops campus policies concerning radiation safety. The RSC approves amendments to the RML and proposed procedures presented by the PIs. The RML is located in the EH&S office and is available for review.

On January 1, 1994, federal and state agencies adopted the International Committee on Radiological Protection (ICRP) good practice philosophy and scientific basis for determining radiation doses by incorporating them into Title 10, Part 20 of the Code of Federal Regulations (10 CFR 20), and California Code of Regulations (CCR) Title 17, respectively.

B. As Low As Reasonably Achievable (ALARA).

Good radiological practices are not new objectives. The National Council for Radiation Protection (NCRP) and ICRP have presented guidance for determining that radiation doses to workers and members of the public is ALARA. The revised 10 CFR 20 requires licensees to establish and maintain ALARA programs. It is the policy of this university that all necessary provisions will be made to facilitate the safe handling of radioactive material and that all operations will be conducted in such a manner that radiation exposures will be kept at levels that are both a small fraction of the allowable limits and ALARA.

C. Radiation Use Authorizations (RUA)

PIs who plan to work with radioactive materials or radiation producing machines must submit a completed application along with a statement of training and experience to the Radiation Safety Officer (RSO) in the EH&S Department. Applications may be obtained by calling EH&S at 594-6778.

The RSO will review the application for completeness and applicability with license conditions. The application will be presented to the RSC for final review. The committee will consider the following items in its final evaluation for granting the RUA.

- Proposed Radionuclides
- Training and Experience of PI
- Laboratory Facilities
- Proposed Procedure and License Conditions
- Order and Experiment Activities
- Waste Streams and Effluents
- Monitoring and Bioassay Requirements
- Posting and Labeling

Upon approval by the RSC, the RSO will generate a RUA that details the use and storage locations, radioisotopes, radiological precautions, monitoring requirements, and Radiological Safety Index (RSI). The RUA must be signed by the PI, Department Chair, RSO and the RSC Chair. A copy of the RUA will be posted in the laboratory. The original will be filed in the EH&S office.

A summary of the RUA process is as follows:

1. Obtain a RUA application and "Statement of Training and Experience" form from EH&S.
2. Complete the forms with significant detail and clarity and return to the EH&S office.
3. RSO will review forms for completeness and submit to RSC.
4. RSC will review the documentation and approve or deny the application.
5. A RUA form and number will be generated for approved applications and those denied will receive notification of reasons why the application was denied.
6. A copy of the RUA will be posted in the laboratory and the original filed at the EH&S office.
7. Training will be provided to the laboratory staff, waste receptacles will be provided by RS personnel and the laboratory(s) will be posted as a controlled area.

D. RUA Amendments, Renewals and Termination

1. Amendments

   The PI should submit requests for amendments to RUAs to the RSO in writing. The proposal is reviewed by the RSO to determine if the amendment requires RSC approval. (Similar procedures with moderate increases in activity are approved by the RSC Chair and the RSO). If the RSC Chair and RSO approve the proposal, it is presented to the RSC during the next meeting as an informational item. Any committee member may bring the item up for action by the committee if safety concerns exist. Amendments requiring RSC approval are presented during the next committee meeting where a majority vote grants amendment approval.

2. Renewals

   Authorization to use radioactive material or radiation producing machines is valid for a period of one year. At the beginning of each calendar year the RS Office distributes a renewal package to each PI holding a valid RUA. The package contains a "Statement of Understanding" to be signed by the PI and an "Annual Retraining Signature Form" to be signed by each authorized user working under that RUA. Renewal of the RUA is contingent on the timeliness of the paper work and an audit of the RUA and laboratory performed by the RSO or his designee. This audit focuses specific attention on items such as changes in procedure, incidents, exposure levels, accuracy of inventory, waste handling, and training. The RSO will present the status and relevant information to the RSC. RUA violations noted during the audit shall be submitted to the PI for correction. A follow-up audit may be performed to ensure corrective actions are addressed. Safety concerns shall be addressed and corrected during the audit if deemed necessary by the RSO.

   Continuance of the user's authorization will be contingent on the results of the annual audit and paper work. If the authorized user is in compliance with the original conditions of the RUA and requests to continue work, the RUA is deemed current and valid by the RSC.

3. Termination

   a) Any authorized user found to be willfully and/or negligently violating any federal, state, or campus regulations governing the use of radioactive material or radiation producing machines will have their authorization suspended or revoked by the RSO, with the concurrence of the RSC. All radioisotopes or radiation producing machines will be impounded.

   b) Authorization for use of radiation will be terminated at the request of the PI. This request should be sent to the RSO by electronic mail or by memorandum.

   c) Termination of the RUA may occur if the PI fails to annually renew their RUA.

   Upon termination of the RUA, all radioisotopes shall be accounted for to the RS Office. All waste shall be removed and transferred to the waste facility. A decommissioning survey will be performed by the radiation safety staff. Once the laboratory is considered radiologically "clean" all signs and postings will be removed.

4. Extended Leave by PI

Any PI leaving the campus for an extended period of time must terminate their RUA, dispose of the radionuclides under their control and have an exit survey, or notify the RS Office that an alternate will be designated as the responsible person to assume authority (i.e., an alternate PI).

E. Radiological Safety Index (RSI)

Each RUA will be assigned a RSI to determine the radiological risks associated with each approved radioisotope, its quantities, and intended use. The RSI is used by the RS Office for determining monitoring frequency and evaluating the use of engineering controls and safety equipment. The RSI is used as a guide and is not the single deciding factor for these determinations. The RSO may adjust a monitoring frequency for a laboratory from quarterly to monthly if repeat violations of RUA conditions warrant increased surveillance.

RSI is determined as follows:

RSI = $\sum_i$[(IV*Q)/IRF + (EV*Q)**Error! Bookmark not defined.**/ERF]

$\sum_I$	is the summation for each isotope approved on the RUA
RSI	is the Radiological Safety Index
IV	is the Internal Value based on the ALI in 10 CFR 20, (mCi)
EV	is the External Value based on Gamma constant Γ in (R-cm^2/h-mCi)
Q	is based on the activity of the radioisotope
IRF	is the internal reduction factor
ERF	is the external reduction factor

Internal Value (IV)

The Internal Value is based on the Annual Limit on Intake (ALI) located in Appendix B of the 10 CFR 20. The most conservative ALI is used, i.e., between ingestion, inhalation and stochastic and non-stochastic values, the lowest value is used. The ALIs are broken out in four groups. An Internal Value is assigned based on which group the ALI for that isotope falls into. Group one has an IV of one, group two has an IV of two, etc. Examples are:

Internal Value (IV)	Annual Limit on Intake	Isotope (examples)
1	>10 mCi	^{3}H, ^{51}Cr, ^{11}C, ^{99m}Tc
2	1 mCi < ALI ≤ 10 mCi	^{14}C, ^{24}Na, ^{35}S, ^{33}P
3	0.1 mCi < ALI ≤ 1 mCi	^{22}Na, ^{32}P, ^{36}Cl, ^{137}Cs, ^{75}Se
4	0.01 mCi < ALI ≤ 0.1 mCi	^{125}I, ^{131}I, ^{60}Co, ^{109}Cd

External Value (EV)

The External Value is based on (Γ) gamma constants in (R-cm^2/h-mCi) provided by the Radiological Health Handbook. The value of the isotope's gamma constant is used to determine the EV based on the following table.

External Value (EV)	Γ gamma constant (R-cm2/h-mCi)	Isotope
1	≤ 1	^{99}mTc, ^{51}Cr, ^{125}I

2	$1 < \Gamma \leq 5$	^{131}I, ^{137}Cs, ^{54}Mn
3	$5 < \Gamma \leq 10$	^{58}Co, ^{56}Mn, ^{59}Fe
4	$10 < \Gamma$	^{60}Co, ^{88}Y, ^{24}Na

Quantity (Q)

The Quantity (Q) is the total on-hand limit allowable in the RUA for a particular isotope. This value does not include waste totals in waste receptacles ready for pick-up. Quantity values are grouped by the following scheme:

Quantity Value (Q)	**Total Activity**
1	≤ 0.1 mCi
2	0.1 mCi < Q ≤ 1 mCi
3	1 mCi < Q ≤ 10 mCi
4	10 mCi < Q ≤ 100 mCi
5	100 mCi < Q ≤ 1 Ci
6	1 Ci < Q

The IRF and ERF are used to adjust the RSI if the RSO or reviewer finds that engineering controls, procedures, or the nature of the compound will reduce the potential for intake or external exposure. Although the nature of these factors generally reduce the safety factor, the RSO, in some cases, may use a number less than 1 to raise the RSI to account for potential dose concerns. The IRF and ERF shall range between 0.5 and 5 and should routinely be 1.0.

F. Clean Area Policy (see definition pg. 43)

Laboratories that maintain "Clean Areas" shall adhere to the following policy endorsed by the RSC and administered through the RS Office. This policy shall not circumvent the current "Food and Beverage in Laboratory Areas" policy implemented by the SDSU Academic Senate on May 6, 1991. Instead, this policy incorporates additional requirements for those laboratories with RUAs. The policy became effective in June 1997.

Clean Area Policy for Laboratories with Current RUAs

- Clean Areas shall be clearly separated from the rest of the laboratory by tape or physical barrier and posted with signs forbidding the introduction of radioactive material.

- Laboratory bench tops within three feet of the clean area perimeter shall have a physical barrier (such as a thin Plexiglas) attached to the end of the bench top to prevent migration of loose radioactive material to the clean area.

- Laboratory personnel shall perform and document weekly surveys of the clean area using the appropriate survey instrument for direct frisks and a minimum of five wipes to be counted using a liquid scintillation counter. A calendar week starts on Sunday and ends on Saturday. Survey results must be maintained in the laboratory for a period of six months at which time the records are forwarded to the RS Office.

- A distance of at least three feet must be maintained between the perimeter of the clean area and any radioactive material either in storage or in use. A solid physical barrier permanently attached to a wall or floor and at least six feet high provides an exemption for this requirement at the specific location if approved by the RSC.

Enforcement Policy:

A violation is defined as any deviation from the conditions previously described and/or radioactive material contamination detected (greater than twice background) inside the clean area.

- The first violation will require a response from the PI to the RSC identifying reason(s) for the violation and presenting corrective action(s) to prevent recurrence. The laboratory shall be placed on a six month probation.
- If a second violation occurs during the probation period or two concurrent violations are noted, the laboratory will be placed on one year probation and daily surveys shall be performed for three months.
- If a third violation occurs during the probation period or three concurrent violations are noted, the laboratory shall, in addition to enforcement for two violations, erect physical barriers restricting access through a single point where hand and foot frisks will be required before entry.
- A laboratory receiving four violations shall lose their clean area privilege permanently.

Chapter 4. Dosimetry

A. General Information

Personnel who use radioactive material and radiation producing machines at San Diego State University generally do not require monitoring in accordance with state and federal regulations. These regulations, as stated in 17 CCR and 10 CFR 20, require monitoring for persons who are likely to receive 10% of the annual dose limit. Historically, the doses received by personnel at SDSU are well below 10% of the annual dose limit and are frequently below reporting levels. However, the university has set its own criteria for monitoring in order to assess health physics practices in accordance with its ALARA policy.

B. Regulatory Limits

1. The annual limit is the more limiting of either:
   a) The total effective dose equivalent being equal to 5 rems (0.05 Sv); or
   b) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).
2. The annual limits to the lens of the eye, to the skin, and to the extremities are:
   a) An eye dose equivalent limit of 15 rems (0.15 Sv).
   b) Shallow dose equivalent of 50 rems (0.5 Sv) to the skin or to any extremity.
   c) Radiation dose to a minor (under the age of 18) shall be 10% of the above limits.

C. Monitoring for External Radiation

1. Types of Dosimeters

Dosimeters are used for recording personnel exposures from external sources. Dosimeters measure energy deposition (dose) from x-rays, gamma, beta and neutron radiation by storing the energy until it is released by measuring equipment yielding an output proportional to the deposited energy. The RS Office distributes two types of dosimeters, one to measure dose to the whole body and a finger ring dosimeter to measure extremity dose to personnel involved in hands-on procedures.

Self-Reading Dosimeters (SRD) may be issued for special circumstances where monitoring is not required but surveillance of potential exposures is warranted. Individuals are trained by the RS Office to properly use, store and read SRDs.

2. Issuing Dosimetry

Dosimeters are issued to university personnel who are using radionuclides emitting energetic beta for typical biochemistry procedures, gamma or x-rays in loose or sealed form, and alpha emitters designed to generate neutrons. Personnel using radiation producing machines such as the XRF, XRD and diagnostic x-ray machines are issued dosimeters. Frequently a finger ring dosimeter is issued along with the whole body dosimeter.

Dosimeters provide legal records of radiation dose. Therefore, it is imperative that they only be used as prescribed. They must be worn at all times while working with radionuclides or radiation producing machines. NEVER wear another person's dosimeter. Each dosimeter is assigned to an individual and tracked by the "red I.D. number". The RS Office exchanges dosimeters on a quarterly basis. They must be stored in a designated location within the PIs principal laboratory away from radiation sources.

3. Lost Dosimetry

Personnel who lose or damage dosimeters will be required to fill out a "Lost Dosimeter Report Form" to properly assess their dose.

4. Positioning

The dosimeter should be worn in the middle of the whole body or as close as practical. The finger ring dosimeter measures extremity dose and shall be worn on the hand most frequently handling radioactive material. The finger ring dosimeter shall be worn under the glove with the detector facing the palm or inside of hand.

5. Records and Prior Exposure

The RS Office maintains all dosimetry records for the university as required by regulatory agencies and the RML. Monitored personnel may obtain records of their dose history by submitting a signed request to the RS Office.

6. Evaluation Level

The evaluation level for dose received by an external source and measured by a dosimeter is $1/50^{th}$ of the corresponding dose limit. This evaluation level may appear extremely conservative; however, its selection is commensurate with doses received at the university without impacting the laboratory with undue scrutiny while providing reasonable assurance personnel doses are kept ALARA.

D. Monitoring for Internal Radiation

Bioassays are performed for the assessment of radionuclide intake and deposition in the worker's body, adequacy of radiological controls and determining compliance with occupational dose limits. Bioassay measurements may be made in-vivo or in-vitro depending on the radionuclide. Bioassays shall be performed if an individual suspects a potential intake, in the event of an accidental loss of containment with significant activity, if an individual meets routine bioassay requirements, or at the discretion of the RSO.

1. Bioassays for Radioiodine

Any individual who introduces into a physical or chemical process <u>at any one time</u> a quantity of radioiodine that meets or exceeds the quantities listed below must be monitored.

Prior to use the individual should have a baseline bioassay. Within 72 hours of the first use a bioassay shall be performed. The individual may continue use of radioiodine for the remainder of the calendar quarter without another bioassay.

At the end of the quarter or upon termination of radioiodine use a bioassay shall be performed. If an individual does not use radioiodine for more than three months, a 72-hour bioassay will be required upon start up.

Radioactivity Levels for Iodine -125 Requiring Bioassay

Process Area	Volatile	Bound
Open room or bench top	100 uCi	1 mCi
Fume hood	1 mCi	10 mCi
Glove box	10 mCi	100 mCi

2. Bioassays for Tritium

Any individual who introduces into a physical or chemical process at any one time a quantity of tritium that meets or exceeds the quantities listed below must be monitored.

Prior to use the individual should have a baseline bioassay. If laboratory monitoring results indicate the potential for internal contamination, the RS Office shall require monitoring.

Radioactivity Levels for Tritium Requiring Bioassay

Process Area	Condition A	Condition B	Condition C
Open room or bench top	10 mCi	10 Ci	1 mCi/kg
Fume hood	0.1 Ci	100 Ci	10 mCi/kg
Glove box	1 Ci	1 kCi	0.1 Ci/kg

Condition A – Tritiated water and tritiated organics including DNA precursors
Condition B - Tritium gas in sealed process vessels
Condition C – Tritiated water mixed with more than 10 kg of inert H_20 or other material

Note: For declared pregnant workers these values are divided by 10.
For routine bioassay program the values are multiplied by 10.

3. Radioactivity Levels for Other Radionuclides Requiring Bioassays

Radionuclides such as P-32, S-35, and C-14 historically do not warrant bioassays. An evaluation will be performed during requests for RUAs or RUA amendments.

E. Means of Controlling Radiation Exposure

1. General Policy

It is the policy of the university that all necessary provisions will be made to facilitate the safe handling of radioisotopes and radiation producing machines, and that all operations will be conducted in such a manner as to maintain exposure ALARA.

These policies as prescribed by the RSC are maintained in this manual with additional precautions and conditions specific to the laboratory listed on the RUA.

2. Controlling External Exposure

There are three general principles for reducing personnel dose from external sources of radiation. These are time, distance and shielding. Typically, more than one of these principles will be applied for reducing dose. Careful evaluation of the anticipated work may dictate which principles will be most effective. For example, shielding will reduce exposure, however excessive shielding may prolong the time an individual spends working with the material resulting in a larger dose. Always bear in mind all three principles when working with radioactive material.

a) Time

Reducing the time you spend handling radioactive materials reduces the dose proportionally. Have your protocol posted or available during the procedure and perform "dry runs" with non-radioactive material during preplanning evaluation of radiation exposure. For all new work, an estimation of radiation dose is a fundamental aspect of good health physics practices.

b) Distance

Increasing the distance from the source is frequently the most effective and economical means to reduce radiation exposure from gamma rays and other highly penetrating radiation. The radiation field varies inversely with the square of the distance. For this reason, tongs and other remote handling tools should always be used for manipulating radioactive material emitting significant levels of radiation. Radioactive material should never be handled with the fingers. Low-level sources can be handled with short forceps, which provide a large reduction in exposure when compared with direct skin contact.

c) Shielding

Appropriate shielding of the source may be used in conjunction with time and distance to reduce exposure to levels which are ALARA. Shielding for gamma radiation is accomplished by placing materials of high atomic number and density between the source and the area to be shielded.

Beta radiation of significant energy (> 1 MeV) can be shielded by using a solid material such as Lucite™ (acrylic polymer) to absorb the radiation. Beta radiation produces penetrating x-rays, called Bremsstrahlung radiation, when it strikes materials of high atomic number. The intensity of Bremsstrahlung radiation varies directly with the square of the energy of the beta radiation and the average atomic number of the shielding material. For this reason, low atomic number materials such as Lucite™ or glass should be used for shielding beta radiation. When working with energetic beta emitters, care must be taken to avoid exposing hands to unshielded material. Dose rates can be on the order of hundreds of rads per minute for commonly used quantities of beta emitters such as P-32. For radioactive materials which emit both beta and gamma radiation, shielding consideration will be determined by the gamma radiation.

3. Controlling Internal Exposure

Internal deposition of radioisotopes is a direct result of mishandling radioactive material. Properly written procedures, evaluation of potential hazards, performing dry runs, and personnel protective clothing all contribute to reducing the potential for dose from internally deposited radioisotopes. Time, distance and shielding are not viable methods for protection when the source of radiation is incorporated into the body. The pathways for radioactive material to enter the body are: inhalation, ingestion, injection or absorption through the skin. Potential exposure pathways at SDSU that require safety evaluations are inhalation and ingestion. Absorption, generally observed with tritium, requires its own engineering controls.

Common sense and proper contamination control procedures will prevent ingestion or inhalation of radioactive material in most cases. A common rule for contamination control is "clean to clean" and "hot to hot." In other words, if you are wearing gloves to prevent your hands from being contaminated, only touch those items which are likely to be contaminated or may be contaminated. Only touch clean items if you have verified that your gloves are clean.

4. General Laboratory Safety Rules

a) No individual is to work with radioactive materials or radiation sources without prior knowledge and understanding of the possible exposure to be incurred and the means available to control exposure as defined by the university's ALARA policy.

b) Eating and drinking are prohibited in laboratories where radioactive materials are stored or used with the exception of "clean areas" approved by the RSC. EH&S recommends no food or drink in labs. Smoking is prohibited in all university buildings.

c) Protective gloves and laboratory coats are required for all operations involving radioisotopes in the laboratory. Additional protective clothing or double gloving may be required if a particular procedure presents a likelihood of contamination or other toxics are involved.

d) Solutions containing radioactive material shall NOT be pipetted by mouth.

e) A catch pan or secondary container of non-breakable material must be used under any vessel or equipment which may leak, burst or spill radioactive material.

f) Laboratory personnel should monitor themselves for contamination before leaving the work area. The RS Office should be notified immediately about contaminated areas or personnel so corrective action can be taken.

g) Operations with radioactive material that could lead to production of aerosols are to be performed in a certified fume hood or glove box.

h) Radioactive materials shall not be removed from posted controlled areas without the authorization of the PI.

i) Radioactive material being transferred between adjacent rooms shall be sealed and carried in an appropriate container. All transfers of radioactive material off campus shall be handled by the RS Office. Facilities for safe storage of radioactive material are provided by the RS Office.

j) Refrigerators, freezers or cold rooms shall not be used to jointly store consumables and radioactive materials.

k) Containers or utensils normally used for food or beverages shall not be used for storing or handling radioactive materials.

l) Radioactive material and sealed sources shall be manipulated with forceps or tongs of suitable length when appropriate.

m) If possible, contaminated hands should be carefully washed and monitored before touching the face, body or items not designated for radiation use.

n) All radioactive material must be labeled and stored in approved areas.

o) Return radioactive material and radiation sources to proper storage when not in use.

p) All primary containers in which radioactive materials are used or stored shall be labeled in accordance with Chapter 6.E.1.b of this manual.

F. Prenatal Radiation Exposure

1. General Information

Employers of radiation workers shall provide instruction on risks from exposure to radiation. Of special interest is the potential exposure of women workers of child bearing age and risks to the unborn child. Children are more sensitive to radiation than adults. The unborn are generally more sensitive than children, especially during the first trimester. Therefore, the acceptable dose limits are lower than for adults.

The 10 CFR 20 requires that the dose to an embryo/fetus during the entire pregnancy from occupational exposure of a declared pregnant woman does not exceed 500 mrem (5mSv). The 10 CFR 20 also requires the licensee to make efforts to avoid substantial variation above a uniform monthly exposure to a declared pregnant woman that would satisfy the 500 mrem (5mSv) limit.

SDSU adheres to the recommendations of the National Council on Radiation Protection and Measurements (NCRP) through compliance with the 10 CFR 20. During the gestation period, the maximum permissible dose equivalent to the fetus from exposure to the declared pregnant worker shall not exceed 500 mrem (5mSv).

During initial training of occupational radiation workers, the university's policy is presented and the risks are reviewed. It is very important for the worker to disclose her condition confidentially, whether fact or suspicion, at the earliest possible time to ensure that proper action may be taken.

2. Disclosure Declaration

When the pregnancy has been disclosed by the radiation worker to the RSO or supervisor, instruction is provided regarding rights and responsibilities and the option to declare pregnancy or not. A copy of Regulation Guide 8.13, "Potential Health Risks to Children of Women Who are Exposed to Radiation During Pregnancy," is provided. If the worker declares pregnancy, it must be submitted in writing to the RS Office. The RSO and worker are responsible to ensure the fetus does not receive more than the allowable limits described above. The worker may wish not to declare pregnancy and is then subject to the dose restrictions of all occupational radiation workers. The following facts may aid in the decision to declare pregnancy and assess work conditions:

a) The first trimester of pregnancy is when the fetus is most susceptible to risks from exposure. The decision should be made early.

b) Due to body shielding, the actual dose received by the unborn child will be less than that to the woman in most situations. At SDSU, most occupational exposures are well below the limits recommended for prenatal exposure.

c) The dose to the unborn child can be reduced by decreasing the amount of time spent with radiation, by increasing the distance from the sources and/or shielding the sources from the abdominal area.

d) A pregnant worker may request reassignment to a location where exposure is significantly less or at background levels.

e) There is no need to be concerned about sterility (loss of the ability to conceive children). The radiation dose required to produce sterility is more than 100 times greater than the basic dose limit for adult workers of five rem (50mSv) per year.

3. Once pregnancy is declared in writing by the worker, the RS Office will initiate the following steps:

a) The individual's workload and schedule will be reviewed to evaluate exposures or procedures where the potential exists for radiation exposure.

b) A second dosimeter may be issued in addition to the quarterly whole body dosimeter. The dosimeter will be worn at the abdomen and processed monthly.

c) If the integrated dosimeter reading at the abdomen is greater than 50 mrem during any one month, the workload and procedures will receive a critical review to reduce exposures. When calculated dose to the fetus totals 500 mrem, a transfer to another laboratory or leave is mandatory and the individual shall not use radioactive materials until completion of the gestation period.

Chapter 5. Training

A. General Information

Training is an essential element for establishing sound health physics practices when using radioactive materials or radiation producing machines. Training is required by regulatory agencies and should be commensurate with associated risk. The university's training program is included in the RML and is, therefore, required by law.

B. Initial Use Radiation Safety Training

It is mandatory that all personnel receive training prior to use of radioactive material or radiation producing machines at SDSU. The RS Office will either schedule a training seminar or provide individual training.

New laboratory personnel shall receive an orientation by the PI or laboratory supervisor prior to receiving training from the RS Office. The PI will be required to sign a form indicating orientation has been completed and that additional supervision will be provided to the new employee until he/she has demonstrated proficiency with their use of radioactive material. Once the new employee has received an orientation to the laboratory, read the initial training pamphlet and become familiar with the Radiation Safety Manual, he/she will be given radiation safety training and an exam. Use of radioactive material will be approved with a score of 70% and above. Those who fail the exam will be given additional instruction and a chance to retake the exam.

Call Environmental Health and Safety at extension 46778 to schedule Initial Radiation Safety Training.

Individuals planning to radiation producing machines will receive initial use radiation safety training specific to those machines.

C. Radiation Safety Annual Retraining

Individuals who have received initial use radiation safety training and have worked with radiation for a period of one year are required to participate in annual retraining. Each year during the RUA renewal process the PI is required to have those persons under his/her responsibility re-read the "Radiation Safety Training" pamphlet and sign the signature form. Principal Investigators are also required to sign this form which is issued with the RUA renewal paper work.

The RSC may require attendance at a radiation safety seminar for annual retraining or successful completion of an exam. Computer Based Training (CBT) may also be an option.

D. Radiation Safety Training For Support Personnel

Radiation safety training for support personnel is provided as deemed necessary by the RSO for support staff who frequent controlled areas including physical plant trades and custodial personnel. Although it is very unlikely that these individuals would receive 100 mrem in a year (10 CFR 19.12), training should be provided at the discretion of the RSO and management.

E. Radiation Awareness Training for Other Laboratory Workers

PIs should provide radiation awareness training to their laboratory workers who do not use radioactive materials. This training should cover identification of process areas, labeling, posting, and waste procedures. Emphasis should be placed on security and control of radioactive material.

Chapter 6. Radioactive Materials Control

A. General Information

Radioactive materials are used in teaching and research. Proper control of radioactive materials is essential for maintaining doses to faculty, staff, students and the general public ALARA. This philosophy at the state and federal levels has led to adoption of strict regulations regarding the procurement of radioactive materials, possession limits, receipt procedures, and tracking the material from production to disposal.

The policies set forth in this chapter provide guidance for SDSU personnel to acquire, use, store, process and dispose of radioactive material in a safe and legal manner.

B. Procurement of Radioactive Materials

Authorized PIs may procure radioactive materials listed on their RUA through either SDSU Foundation or SDSU Contract and Procurement Management Departments by using the appropriate Purchase Requisition Form. The completed form must indicate the desired radioisotopes and associated activities. The purchase order should indicate the PI's name and laboratory room number to ensure timely delivery by the RS Office following receipt inspection.

"Open" or "Blanket" purchase orders shall list each radioisotope and associated activity of each shipment and the intended frequency of shipment. Each individual order shall not exceed the limits set on the purchase order.

The RS Office must inspect every package for leakage or damage prior to delivery to the laboratory. In addition, the invoice will be checked against the RUA of the ordering PI. If the material is not an authorized isotope or chemical form or if order limits are exceeded, it will be retained in the RS Office pending resolution.

All purchase orders must designate the following address for delivery of radioactive material to SDSU:

San Diego State University
Radiation Safety Office/EH&S
(PI Name)
CSL 106
5500 Campanile Drive
San Diego, CA 92182-1243

If a package is delivered anywhere other than the RS office, contact EH&S at 594-6778 immediately. A representative from the RS Office will retrieve the package and perform the required inspection.

C. Transfer of Radioactive Material

Transfers of radioactive material between laboratories on campus or between other licensees shall have prior approval from the RS office. The PI requesting the transfer shall submit the Radioactive Materials Transfer Request Form located in the Appendix of this manual to the RS Office. An electronic version of this form is located on the Radiation Safety web page which can be e-mailed to the RSO. Approval is generally granted the same day for transfers between SDSU laboratories.

For transfers between licensees in the San Diego area, the RS Office shall package the material and generate the appropriate paper work in accordance with DOT specifications. For transfers outside the

San Diego area, a common carrier will pick up the material from the EH&S office in CSL-106. The RS Office will package the radioactive material and generate the packing list.

D. Radioactive Material Inventory

State and federal regulations require that a complete and accurate inventory be maintained of all radioactive material. The RS office maintains an inventory by recording all incoming shipments of radioisotopes and the waste generated by each laboratory.

Each quarter, the RS office will distribute a list of recent radioisotope shipments and any amendments from the previous quarterly list to each PI. This list shall be reviewed and a physical inspection of the material shall be performed by the PI or designee. Corrections shall be noted as to the activity of the stock on hand or disposition of the processed material. If all the material has been used during the quarter and is now in waste, indicate "waste" on the form. If an aliquot of stock material has been removed, indicate the amount "used" on the form.

In addition, each PI shall maintain their own inventory of stock of radioisotopes. The record shall include each stock vial, each aliquot removed, date of removal and initials of individual removing the material. These records shall be kept in the laboratory for a period of one year.

The RS Office has created a generic inventory form that is presented in the Appendix.

E. Posting and Labeling

Posting of signs, caution/warning signs, and labels are used to advise personnel of potential hazards with respect to radiation and radioactive materials. The international radiation symbol, warning signs, labels and other such items shall be used only to provide information and warnings to personnel. Any other use is prohibited.

Most laboratories at SDSU are considered controlled areas as defined in this manual.

1. Radioactive Materials Posting

   a) An area or room that contains radioactive materials in excess of the quantities in 10 CFR, Appendix C 20.1001-20.2401, shall be posted with a sign bearing the radiation symbol and the words "Caution Radioactive Materials."

   b) Containers of radioactive materials must be identified by a label, tape or tag. At a minimum the words "Radioactive Material" shall be used. The container must be labeled or have written on the container tag the radionuclide(s) and quantity of material in curies or sub units, or becquerels, in addition to the words "Radioactive Material."

   c) The physical boundaries of the rooms, buildings or areas indicated on a RUA and set up on a permanent basis shall be considered a controlled area as defined in this manual. There shall be at least one copy of Radiologic Health Branch Form RHB 2364, "Notice to Employees," conspicuously posted in the area.

   d) Designated process areas inside the laboratories where radioactive materials are used should have laminated absorbent paper on the lab bench to insulate the surface from contamination and limit the spread of spills. The area should be identified as a process area by defining the perimeter with caution tape or other obvious indication with the words "Radioactive Materials" or "Caution Radioactive Materials."

2. Radiation Area

   a) A radiation area is defined as a room or area where radiation levels are such that an individual could receive 5 millirem or more in one hour at 30 centimeters from the nearest accessible surface of a radiation source.

   b) A radiation area shall be posted with a sign bearing the radiation symbol and the words "Caution Radiation Area."

3. High Radiation Area

   a) A high radiation area is defined as a room or area where radiation levels are such that an individual could receive 100 millirem or more in one hour at 30 centimeters from the nearest accessible surface of a radiation source.

   b) A high radiation area shall be posted with a sign bearing the radiation symbol and the words "Caution: High Radiation Area" or "Danger: High Radiation Area."

4. Airborne Radioactivity Area

   a) If monitoring activities indicate that airborne radioactivity exists in concentrations equal to or greater than 1 DAC or 12 DAC-h/wk as specified in 10 CFR 20 Appendix B (or the combined concentration to DAC ratios of multiple airborne radionuclides is 1 DAC or 12 DAC-h/wk), that area shall be deemed “Restricted" and posted as an Airborne Radioactivity Area.

   b) An airborne radioactivity area shall be posted with signs that have the radiation symbol and the words "Caution: Airborne Radioactivity Area" or "Danger: Airborne Radioactivity Area."

F. Contamination Control / Monitoring

Good laboratory practices, proper monitoring, and pre-planning are essential tools for contamination control and preventing unnecessary exposures to laboratory personnel. The ALARA policy ensures that exposures to personnel are low and that general laboratory procedures include prudent health physics practices.

Each individual user is required to control contamination levels in the laboratory and adjacent areas. Surveys and monitoring should be done during and following material handling and experimental procedures that involve radioactive material. The intent of surveys is to assure timely detection of contamination and prevent the spread of radioactive material throughout the laboratory.

The individual user should verify that the survey instruments have a current calibration sticker and are appropriate for the radioisotope involved. Instrument calibrations are performed by the RS Office staff as a service to the laboratory. If your instrument does not have a current calibration sticker, call EH&S at extension 46778.

The individual users should survey themselves, their laboratory coats and process areas before leaving the area. Other items in the laboratory to be surveyed include work surfaces, equipment, floors, door handles, telephones, refrigerators and freezers, drawer handles and frequently used notebooks. Effective monitoring includes direct measurement using the appropriate instrument and taking wipe samples (Whatman filter papers or equivalent) to be counted with a liquid scintillation counter (LSC) for removable contamination. The recommended instruments are a sensitive, thin-window Geiger Mueller (GM) detector (preferably the "pancake" style) for most beta emitting radioisotopes and a sodium iodide (NaI) probe for I-125 and low energy gamma emitting radioisotopes. Documentation of these surveys is not generally required unless stipulated on the RUA. Documentation of weekly surveys of "clean areas" is mandatory.

When using any portable survey instrument, it is important to follow these general guidelines:

1. Use an instrument which is designed for the specific radiation emission (e.g. GM for beta emitters and NaI for gamma or x rays). *Note: GM detectors cannot be used for tritium; the beta particle will not penetrate the detector window. For tritium, a wipe should be taken and counted in a LSC*.

2. Check the battery and verify calibration prior to performing the survey. Set the instrument to the lowest scale.

3. Note the background count rate or exposure rate in a known low background area prior to performing the survey. If background appears too high (general background for a GM is ~60 cpm and ~250 cpm for a NaI), contact EH&S at extension 46778.

4. While performing the survey, hold the detector as close as possible to the area being surveyed, moving across the surface at a speed of approximately 2 inches per second.

5. Surveyed areas or equipment which exhibit a count rate greater than twice the background count rate are considered contaminated and should be decontaminated. No equipment should remain contaminated.

6. If count rate causes the needle to read full scale, adjust scales as necessary to permit a valid reading. Adjusting scales has no bearing on detector sensitivity.

G. Storage and Security of Radioactive Material

Radioactive material used or stored in controlled areas must be secured from unauthorized access or removal, or shall have constant surveillance by authorized personnel (persons who have received radiation safety training and are considered occupational radiation workers). Laboratories posted with "Caution Radioactive Material" signs must be secured or the radioactive materials themselves be secured whenever a radiation worker is not present.

Laboratory personnel who do not work with radioactive materials may be among those in immediate control of radioactive materials if they have received training by the PI regarding security. Any loss of radioactive material must be **immediately** reported to the RSO and PI.

H. Free Release

Laboratory equipment used in conjunction with radioactive materials or other equipment that is potentially contaminated which must be removed from the process area or controlled area for maintenance, repairs, calibration or other disposition is subject to the following procedures:

1. The item should be thoroughly cleaned and all unassociated material removed (for example: labware and chemicals found in refrigerators, freezers, fume hoods, etc.).

2. The item must be thoroughly surveyed using the appropriate survey meter and by taking wipes to be counted on a liquid scintillation counter.

3. Once the item is free of detectable activity, all radioactive labels and postings must be removed by RS personnel. If you are unable to remove the contamination or label, call the RS Office for assistance.

Chapter 7. Radiation Producing Machines

A. General Information

This chapter covers campus machines capable of producing ionizing radiation when the associated control devices are operated such as medical machines, x-ray irradiators and x-ray diffraction machines.

B. Approval for Acquisition

Departments wishing to use a radiation producing machine shall obtain approval from the RSC prior to acquisition. Notification is required to assure that the machine is registered with the CDPH, safety protocols are written, and the necessary shielding is in place. To obtain approval, the PI should submit the "Request for Radiation Use Authorization," located in this manual, to the RS Office. Information should include:

1. Description of machine (e.g., type of machine, manufacturer, model, year of manufacture, maximum operating parameters, energy and beam current).

2. Operating protocol and typical operating parameters.

3. Interlocks and access control.

After the machine is acquired, the RS Office shall be notified if there is a change in use, design or location of the radiation producing machine or if it is sold, traded, transferred or discarded.

C. Personnel

Persons who will operate radiation producing machines must receive training approved by the RS Office prior to operation of the machine. They shall also receive additional training on operating procedures and safety protocols by the PI. When required, dosimetry shall be worn whenever the machine is producing ionizing radiation. Dosimetry is provided by the RS Office during the initial radiation safety training.

D. Safety Devices

Specific safety devices are required by state and federal agencies for each radiation producing machine. Examples are warning lights, beam enclosures, interlocks, and shielding. All safety devices shall be maintained in good operating condition and shall not be replaced or modified without approval from the RSC. A safety device shall never be purposely defeated. If a required safety device becomes non-operational, the machine shall not be operated until the safety device is repaired and checked by the RS Office.

E. Posting and Labeling

Posting and labeling of radiation producing machines shall be in accordance with state and federal regulations. Rooms that are used for medical diagnosis by x-ray should have a warning light that indicates "X-Ray On" to alert personnel who may inadvertently enter the room during operation of the machine.

Radiation and High Radiation Areas as defined in this manual shall be posted accordingly.

F. Surveys

Unless otherwise specified, the RS Office shall inspect the installation of radiation producing machines prior to use, whether newly acquired, relocated, modified or repaired, to determine the effectiveness and requirements of safety devices. The RS Office shall survey each machine at least annually. Principal users should perform safety checks if required by the RUA.

G. Safety Procedures for Specific Machine Categories

1. Medical X-Ray Machines

An operating log should be maintained by the x-ray technician. All machine operations, installation designs, etc., shall be conducted in accordance with the California Code of Regulations (CCR) and the appropriate NCRPs. All personnel shall wear the required dosimeter assigned to them by the RS Office. Any employee required to be in the room during operation of the x-ray unit shall wear a protective lead apron or stand behind a protective barrier.

2. X-Ray Irradiators and Diffraction Machines

a) Operators of x-ray irradiators and diffraction machines shall maintain an operating log to include: name of operator, beam potential or beam current, date of use, beam on time and warm-up time (if required by machine).

b) X-Ray Irradiators

Irradiators shall be used in rooms such that exposure rates outside the shield room do not exceed 5 mR in any one hour, all doors with access to the room are equipped with interlocks and a visible warning light indicates when the machine is on.

c) X-Ray Diffraction Machines

Open beam x-ray diffraction machines can be hazardous because of the very high primary beam exposure rates at the x-ray tube beam ports. Serious damage can result to eyes and skin even if the exposure time is very short. Extreme caution must be exercised in the use of x-ray diffraction machines. Following are requirements for safe use of x-ray diffraction machines:

(i) The authorized PI is responsible for assuring that x-ray diffraction machines are kept in good condition, that safety systems are functioning, and that the equipment meets specifications.

(ii) Personnel who supervise or operate x-ray diffraction machines are responsible for notifying co-workers, supervisors and the RS Office of any unsafe operating conditions or machine failures.

(iii) Appropriate radiation shielding shall be installed on each x-ray diffraction machine. These shields should be interlocked to prevent radiation exposure to personnel in the event the shield is removed or opened.

(iv) All beam shutter mechanisms shall be interlocked to prevent operation if the shutter is not properly closed.

(v) The authorized PI is responsible for ensuring users are trained. The RS Office shall provide general radiation safety training and the PI shall provide training for machine operations and laboratory procedures.

(vi) All x-ray diffraction machines and use areas shall be labeled with appropriate radiation caution signs, along with the required operational radiation warning lights.

Chapter 8. Radioactive Waste

A. Types of Waste

1. Dry Waste

Dry radioactive waste includes dry solid materials, dehydrated biological materials, and contaminated papers, glassware, gloves, or apparel.

2. Liquid Waste

Liquid radioactive waste includes liquid radioactive materials, solutions, contaminated rinses, suspensions of microorganisms, animal blood, and urine. Liquid wastes are further categorized as aqueous and non-aqueous.

a) Aqueous wastes are those which are readily soluble or dispersible in water.

b) Non-aqueous wastes are those liquids which are not readily soluble or dispersible in water and should include any organic solution which can be segregated from the aqueous waste stream. These include liquids such as organic-based liquid scintillation fluids such as Toluene or Xylene.

3. Biological Waste

Biological waste includes animal carcasses, solid excreta, tissue, organs, etc. Small insects or other easily dehydrated biological materials are not considered biological waste for purposes of this manual. Dehydrated biological materials may fall under different guidelines for biohazards or pathogenic material.

Note: Radioactive bio-hazardous waste must be disinfected prior to pickup by the RS office.

4. Other Waste Materials

a) Plant materials may be included in dry waste if dehydrated.

b) Animal urine containing radioactivity may be included in liquid waste.

c) Liquid animal blood may be disposed of as liquid waste.

d) Used gels may be disposed of as dry waste.

e) Sharps should be placed in a rigid container prior to inclusion in the dry waste container.

B. Responsibilities

1. The RS Office is responsible for:

a) Developing policy and procedures for safe storage, collection, and processing of radioactive waste.

b) Managing the disposal of waste in accordance with the terms and conditions of the university's RML.

2. PIs are responsible for:

   a) Collecting and storing all radioactive waste resulting from activities under their direction in accordance with this manual.

   b) Assuring that the total activity of the container is accurately estimated in accordance with Chapter 11, section D of this manual.

   c) Performing appropriate segregation of waste as directed by this manual or the RS Office.

   d) Labeling waste as required by local, state and federal regulations.

C. Laboratory Radioactive Waste Procedures

1. General

   a) The laboratory must segregate radioactive waste by half-life. Short-lived isotopes such as P-32, S-35, and I-125 require individual waste containers. Longer-lived materials such as H-3 and C-14 may be combined in the same container as long as their activities are listed separately.

   b) Appropriate consideration should be given regarding potential for exposure. Exposure rate is particularly important when working with gamma emitting or high energy beta emitting isotopes. An effort should always be made to keep radiation exposures ALARA.

   c) The radioisotopes in each container must be specified on either the tag or label. A reasonable estimation of the activity must be made for each radioisotope prior to pickup by the RS Office. A GM counter should not be used to estimate the activity of any waste. A reasonable estimate may be made from the use log maintained in the laboratory. In the case of liquid waste, waste can be sampled and counted on a liquid scintillation counter. This data can be used to calculate activity for the entire container.

2. Dry Radioactive Waste

   a) The container for dry radioactive waste may be provided by the RS Office. It will usually come unassembled, with two plastic liners. Laboratory personnel will assemble the box and place both of the liners in the box, one inside the other. All waste containers must be identified with the radiation symbol, the words "CAUTION--RADIOACTIVE MATERIAL" and the radioisotope(s).

   b) No liquids are allowed in dry waste containers. All liquid must be decanted into radioactive liquid waste containers.

   c) Gels may be placed in the dry waste box.

   d) Do not place lead, animal tissue, chemical, bio-hazardous or infectious materials in dry waste container. Any radioactive biohazards or infectious radioactive waste must be disinfected prior to inclusion in the waste box. All biohazard insignias must be defaced before placing in the waste box. If disinfection is not available, the packaged biological material must be immediately frozen and stored in a freezer until collected by the RS Office. If freezing facilities are not available, the RS Office must be notified immediately to arrange prompt collection for freezing or disposal

   e) All liquid scintillation vials and caps previously containing C-14 or H-3 must be emptied and segregated from other dry waste for volume reduction reasons in accordance with federal regulations.

f) All radioactive sharps (e.g. needles, blades, or Pasteur pipettes) must be segregated and secured in a rigid side, puncture proof container prior to their inclusion in the dry waste box.

g) Before the box is full, reasonable attention should be given to estimating the amount of radioactivity present. A label attached to the box provides space for this and other information.

h) The laboratory is responsible for taping the bags closed and sealing the box. Regular masking tape is suitable for this. Call the RS Office at extension 4-6778 or 4-6879 to arrange pickup after the box is sealed and labeled. Usually pickups can be made and new boxes provided the same day. Occasionally we are unable to pick up the waste the same day, so plan ahead to ensure adequate container space is available before starting a procedure.

3. Liquid Radioactive Waste

a) Liquid radioactive waste should be retained only in receptacles provided by the RS Office. The container will typically be a plastic jug which is placed inside a secondary container.

b) Do not put pipettes, pipette tips, vials, sharps, or filters in the waste jug, only liquids.

c) Isotopes should be segregated in the same manner as dry waste.

d) Radioactive solvents which are organic and not readily dispersible in water (e.g., ether, xylene, toluene, hexane, etc.) need to be segregated in separate containers. (The container should be compatible with the waste material.)

e) Do not overfill the container. There is usually a fill line which should not be exceeded. Generally, do not fill beyond 3/4 full. Call the RS Office for a waste pickup when approaching this capacity. Use appropriate pre-planning to ensure sufficient container space is available before starting a procedure.

f) Make sure that the attached tag is filled out detailing the isotope, activity, chemical form, and other requested information.

IMPORTANT: Several brands of non-toxic, biodegradable LSC solutions (e.g., EcoLume, EcoLite, etc.) are commercially available. Biodegradable LSC solutions are considered aqueous for purposes of radioactive waste disposal. Please indicate brand name under chemical form.

Chapter 9. Emergency Procedures

A. Emergency Information

Police - Fire – Emergency………………….**911**

Campus Extension

Public Safety (campus)……………………..59**4-1991**
Environmental Health and Safety…………..59**4-6778 (Business Hours)**
Radiation Safety Office……………………..59**4-6879** or 59**4-4055 (Business Hours)**
(Business hours are Monday through Friday, 8:00 a.m. to 4:30 p.m.)

B. General Response Procedures

In case of emergency, personnel protection and lifesaving measures **must** be addressed first; radiological considerations are secondary. In any emergency, guidelines are used with discretion as circumstances and common sense dictate. Analyze the situation before taking action. All incidents involving radioactive material or radiation producing machines must be reported to the RSO.

If a spill has occurred involving radioactive material, the following steps should be performed:

1. Isolate the spill if possible.

   Use paper towels or other disposable, compatible material to limit the spread of the spill. For dry material and powders, use caution to prevent material from becoming airborne. Place dampened absorbent material over the contaminated area.

2. Notify others in the area that a spill has occurred. Identify what has been spilled. Do not leave the lab unless necessary.

   Informing others in the lab about a spill reduces the potential for tracking contamination. A reasonable distance should be maintained in order to avoid possible spots of contamination outside the apparent perimeter of the spill.

   The type and quantity of radioactive materials typically used at SDSU would not warrant evacuation of the lab unless the spill involves the dispersal of pathogenic or chemical hazards. Personnel should be monitored for contamination prior to leaving the lab.

3. Contact the RS Office at extension 4-6879 or 4-6778.

   It is imperative to contact the RS Office in the event of a spill. Depending on the nature of the incident, it may be necessary to perform a bioassay to detect any uptake of radioactive material by personnel. It is in your best interest to report spills when they occur.

   If outside normal business hours, contact Public Safety at 594-1991. Other emergency phone numbers are posted on the exterior of the laboratory door.

4. Perform decontamination if advised.

   If advised by the RS Office to clean up the spill, remember to put on your dosimetry (if issued) and personal protective equipment (PPE), e.g., a lab coat and gloves. Start cleaning the spill area from the perimeter working carefully toward the center. Be careful not to spread contamination. If a commercial decontamination solution is not available, soap and water will be sufficient. Double bag all cleanup materials.

5. Monitor the area for any remaining contamination.

   The area should be monitored for residual contamination in the same manner as the routine post-procedure monitoring done in the lab. Use the appropriate detection equipment. Refer to Chapter 6, section F of this manual or consult the RS Office if you are unsure of the proper monitoring techniques.

C. Emergency Response to Specific Cases

1. If you suspect that a person has been contaminated with radioactive material, take the following steps:

   a) Wash the affected area immediately.

      Go to the nearest sink or emergency shower and cleanse the area of contamination with soap and tepid water for fifteen minutes. Any clothing that is suspected of contamination or is an impediment to decontamination should be removed. Do not hesitate to enlist the help of a co-worker. Removal will be easier and more successful the sooner skin decontamination is performed. Do not use abrasives.

   b) Contact the RS Office at extension 4-6879 or 4-6778. Do not leave the lab unless necessary.

      The RS Office must be contacted in the event any person becomes contaminated with radioactive material. The extent of contamination must be established to ensure that decontamination efforts are adequate. The victim should not be engaged in activities other than decontamination until the situation can be assessed by RS Office representatives.

2. If there is an airborne release of radioactive material take the following precautions:

   a) Do not attempt to clean the area.

   b) Close all windows, leave the room and lock the door. Advise Physical Plant to turn off ventilation system.

   c) Keep non-emergency personnel from entering the room and all persons involved in the incident in a contained area outside the room until monitoring can be performed.

D. Things you can do to help prevent an incident:

1. Periodically discuss laboratory safety and contamination control during your laboratory meetings.

2. Review the operational reminders in the "How do I…" section of this manual (Chapter 11).

3. Periodically perform a safety survey of your laboratory to identify possible safety concerns. Correct those you identify.

4. Routinely inspect any safety or measurement equipment in the lab.

5. Post a copy of your radioactive material inventory where it can be seen by emergency responders.

6. Be cognizant of potential hazards in the laboratory and make sure they are appropriately labeled or remediated.

7. Have a designated location for this manual and any other safety reference material.

8. Maintain a spill response kit in each laboratory. The radiation kit should include the following recommended items:

<Decontamination solution	<Trash bags
<Shoe covers	<Contamination wipes
<Disposable towels	<Box of disposable gloves
<Tape	<Marking pen

Chapter 10. Technical Data on Common Radioisotopes

A. Tritium (^{3}H)

^{3}H is a radioisotope which emits very low energy beta particles as it decays. It is commonly used as a radiotracer in life sciences research as a result of the abundance of hydrogen in molecules of biological importance.

Physical Data

^{3}H decays to ^{3}He (which is stable) by beta emission
Half-life = 12.3 years
Maximum beta energy (E_{max}) = 0.0186 MeV
Average beta energy (E_{avg}) = 0.0057 MeV
Maximum range in air = Approximately 0.152 inches (0.387 cm)
Maximum range in tissue = Approximately $2.0x10^{-4}$ inches ($5.0x10^{-4}$ cm)

Metabolic Data

The fate of ^{3}H taken into the body is influenced primarily by the type of molecule on which it is attached and the route of entry into the body. The ^{3}H may be inhaled, ingested or absorbed through the skin as tritiated water, or it may be ingested as labeled organic compounds. For radiation protection purposes, it is estimated that essentially all of inhaled ^{3}H (in the form of tritiated water) is absorbed by the lungs, and all of the tritiated water entering the GI tract is absorbed by body fluids. When tritium enters through the lungs or GI tract, maximum blood concentrations are reached within two hours. Of the ^{3}H absorbed from the lungs or through the GI tract, about 99 % is eliminated with a relatively short biological half-life (ICRP 30) of about 10 days. ^{3}H labeled DNA (in most cases thymidine) shows a much longer biological half-life. Some studies have shown that if ^{3}H-thymidine is injected, approximately 50% will be incorporated into cellular DNA. If ^{3}H-thymidine is ingested, approximately 10% will be incorporated into cellular DNA. Since DNA is a relatively stable molecule and numerous DNA "salvage" pathways exist, the estimated biological half-life for tritium labeled nucleotides is on the order of 50 times that measured for tritiated water.

There is concern that ^{3}H on labeled DNA or DNA precursors may pose special problems because of the location of the radioactive atom on sensitive molecules within the cell nucleus (approximately 0.34 rad/cell-nucleus-decay). Transmutation events caused by the decay of ^{3}H to ^{3}He could also have detrimental effects. This problem has been studied extensively and the findings indicate that the principal damage which results is caused by the radiation dose averaged throughout the tissue, not by localized effects.

Based on these metabolic data, and because there are no gamma rays emitted to facilitate in-vivo measurement, excreta measurements (urinalysis or fecal analysis) are the appropriate bioassay types for assessing intake and dose.

The Annual Limit of Intake (ALI) for occupationally exposed persons is 80 mCi for ingestion and inhalation of tritiated water.

Radiation Monitoring and Protection

Because of its weak beta emission, Hydrogen-3 is primarily an internal radiation hazard. Dosimeters are not effective for detecting ^{3}H. Therefore, it is important to use careful handling and frequent monitoring. Taking wipe samples and counting in a liquid scintillation counter is necessary. ^{3}H vessels can be handled directly with gloved hands since the dose rate outside the vessel is low.

B. Carbon-14 (^{14}C)

^{14}C is a radioisotope which emits relatively low energy beta particles as it decays. It is commonly used as a radiotracer in life sciences research due to the abundance of carbon in molecules of biological importance.

Physical Data

^{14}C decays to ^{14}N (which is stable) by beta emission
Half-life = 5730 years
Maximum beta energy (E_{max}) = 0.156 MeV
Average beta energy (E_{avg}) = 0.05 MeV
Maximum range in air = Approximately 10 inches (25 cm)
Maximum range in tissue = Approximately 0.01 inches (0.025 cm)

Metabolic Data

The fate of ^{14}C taken into the body is influenced primarily by the type of molecule on which it is attached and the route of entry into the body. The ^{14}C may be inhaled as CO or CO_2, or it may be ingested as labeled organic compounds. For radiation protection purposes, it is estimated that essentially all of inhaled ^{14}C is absorbed by the lungs, and all of the ^{14}C entering the GI tract is absorbed by body fluids. Of the ^{14}C absorbed from the lungs or through the GI tract, about 99% is eliminated with a very short biological half-life (minutes to hours), while 1% is retained in soft tissue with a half-life of about 40 days.

Based on these metabolic data, and because there are no gamma rays emitted to facilitate in-vivo measurement, excreta measurements (urinalysis or fecal analysis) are the appropriate bioassay type for assessing intake and dose.

The Annual Limit of Intake (ALI) for occupationally exposed persons is 2.0 mCi for ingestion of labeled compounds, 2000 mCi for inhalation of CO and 200 mCi for inhalation of CO_2.

Radiation Monitoring and Protection

Because of its relatively weak beta emission, ^{14}C is primarily an internal radiation hazard. External dosimetry is not effective for detecting ^{14}C. Therefore, it is important to use careful handling and frequent monitoring, either with survey meters with thin-window probes or by taking wipe samples and counting in a liquid scintillation counter. Carbon-14 vessels can usually be handled directly with gloved hands since the dose rate outside the vessel is low.

There is concern that ^{14}C on labeled DNA or DNA precursors may pose special problems because of the location of the radioactive particle on sensitive molecules within the cell nucleus. Transmutation events, caused by the decay of carbon to nitrogen, could also have detrimental effects. This problem has been studied extensively, and the findings indicate that the principal damage which results is caused by the radiation dose averaged throughout the tissue, not by localized effects.

C. Sulfur-35 (^{35}S)

^{35}S is a radioisotope which emits relatively low energy beta particles as it decays. It is commonly used as a radiotracer in life sciences research, usually in the form of labeled amino acids or nucleotides.

Physical Data

^{35}S decays to ^{35}Cl (which is stable) by beta emission
Half-life = 87.2 days
Maximum beta energy (E_{max}) = 0.167 MeV

Average beta energy (E_{avg}) = 0.048 MeV
Maximum range in air = Approximately 11 inches

Metabolic Data

The fate of ^{35}S taken into the body depends primarily on the type of molecule on which it is attached. For radiation protection purposes, the following are usually assumed:

Inorganic compounds: About 80% of ^{35}S inorganic compounds entering the GI tract is absorbed by body fluids, while about 10% of the elemental form is absorbed. Of the ^{35}S absorbed by body fluids through the GI tract or from the lungs, about 20% is deposited in various soft tissues, while 80% goes directly to excreta. Of the amount retained, 75% is eliminated with a biological half-life of 20 days, while the remaining 25% is eliminated with a half-life of 2000 days. For inhalation cases, the retention of ^{35}S in the lungs ranges from days to weeks depending on the solubility of the compound.

Organic compounds: The metabolic behavior of organic compounds of sulfur differs considerably from that of inorganic forms of the element. Organic forms such as cysteine and methionine become incorporated into various metabolites. Thus, sulfur entering the body as an organic compound is often tenaciously retained. Little or no data is available on the specific retention and distribution pattern of ^{35}S labeled organic compounds.

Based on these metabolic data, and because there are no gamma rays emitted to facilitate in-vivo measurement, urinalysis is the appropriate bioassay type for assessing intake and dose.

The Annual Limit of Intake (ALI) for occupationally exposed persons ranges from about 2 mCi to 20 mCi depending on the chemical form and the route of entry into the body.

Radiation Monitoring and Protection

Because of its relatively weak beta emission, ^{35}S is primarily an internal radiation hazard. Dosimeters are not effective for detecting ^{35}S. Therefore, it is important to use careful handling and frequent monitoring, either with survey meters with thin-window probes or by taking wipe samples and counting in a liquid scintillation counter.

^{35}S vessels can usually be handled directly with latex gloved hands, since the dose rate outside the vessel (caused by brehmsstrahlung radiation) is low. Plastic gloves will not protect the hands from brehmsstrahlung radiation.

Solutions of ^{35}S -labeled amino acids release a volatile radioactive component which can pose containment problems. The chemical identity of this volatile component is unknown, although SO_2 and CH_3SH are likely candidates. The volatile component appears to evolve as a result of chemical/physical breakdown, not metabolic activity. This volatilization can result in the contamination of incubators and their contents.

To prevent volatilized ^{35}S from entering the breathing zone, it is recommended that vials of ^{35}S amino acids be thawed in a fume hood using a needle through the rubber septum to vent the vial. Alternatively, a syringe packed with charcoal could be attached to such a needle. Incubators and related equipment should be checked frequently for contamination.

D. Phosphorus-32 (^{32}P)

^{32}P is a radioisotope which emits relatively high energy beta particles as it decays. It is commonly used as a radiotracer in life sciences research because of its abundance in molecules of biological importance.

Physical Data

^{32}Pdecays to ^{32}S (which is stable) by beta emission
Half-life = 14.3 days
Maximum beta energy (E_{max}) = 1.71 MeV
Average beta energy (E_{avg}) = 0.69 MeV
Maximum range in air = Approximately 6 meters
Dose rate from 1 mCi of unshielded ^{32}P over an area of 1 cm^2:

2,000 rem/hr at contact
200 rem/hr at 1 cm
22 rem/hr at 10 cm

Dose rate from 1 mCi of P-32 in 1 ml of solution:

780 rem/hr (or 13 rem/min) if unshielded
2 rem/hr at 1 cm if shielded by normal glassware (due to production of brehmsstrahlung or X-rays)

Dose rate from 10 mCi of ^{32}P in 25 ml flask filled with water is about 0.3 mrem/hr at 10 cm.

Metabolic Data

The fate of ^{32}P taken into the body is influenced primarily by the type of molecule on which it is attached. For radiation protection purposes, it is usually assumed that 80% of ^{32}P entering the GI tract is absorbed by body fluids. Of the ^{32}P absorbed from the lungs or through the GI tract:

1. About 30% is deposited in bone where it is retained until the P-32 decays (stable phosphorus is retained in bone with a biological half-time of 1500 days).

2. About 55% is distributed in soft tissue from which it is eliminated with two distinct half-lifes: 15% with a half-life of 2 days, and 40% with a half-life of 18 days.

3. 15% is immediately excreted.

Based on these metabolic data, and because there are no gamma rays emitted to facilitate in-vivo measurement, urinalysis is the appropriate bioassay type for assessing intake and dose.

The Annual Limit of Intake (ALI) for occupationally exposed persons is 0.6 mCi for ingestion and 0.9 mCi for inhalation.

Radiation Monitoring and Protection

Dosimetry should be worn by all personnel working with P-32. If millicurie amounts are manipulated, finger rings should also be worn.

^{32}P vessels should not be handled directly by hands unless the radioisotope solution is in dilute form. Plastic gloves will not protect the hands from brehmsstrahlung radiation.

The most effective shielding materials are those that have a low effective atomic number (Z) since brehmsstrahlung production increases linearly with the Z of the absorber. For glass, about 1% of the beta energy is converted to x ray energy.

Beta absorption is relatively independent of atomic number so plastic, glass, wood and other low-Z materials provide shielding which is just as effective at stopping ^{32}P beta particles as an equal mass of lead or iron, producing fewer x rays in the process.

The most effective ^{32}P shield is one which utilizes a low-Z inner shield to absorb the beta particles and minimize x-ray production, and an outer layer of lead or iron to absorb the x rays produced in the inner shield. Usually, 1/4" of lead will be adequate for up to several millicuries. If the high-Z material were used as the inner layer, the shielding effectiveness would be less.

Because most ^{32}P stock solutions are of small volume, the inverse square law applies. Significant reductions in dose can be achieved by remote handling. For example, the dose rate at 1 cm from a small vial containing 1 mCi of ^{32}P is about 2000 mrem/hr. At 1 inch, the dose rate is about 350 mrem/hr and at 2 inches decreases to about 80 mrem/hr. The inverse square law is only valid when the distance is greater than 3-4 times the effective diameter. Dose reduction would be less for sources of larger diameter. A 1-inch diameter source yielding 2000 mrem/hr at 1 cm, for example, would be reduced to only about 1000 mrem/hr at 2 inches.

E. Iodine-125 (^{125}I)

^{125}I is a highly volatile radioisotope which emits relatively low energy x-ray radiation as it decays. ^{125}I is commonly used as a radiotracer in life sciences research as well as in clinical applications. The inhalation or ingestion of ^{125}I can result in a serious dose to the thyroid gland.

Physical Data

^{125}I- decays to ^{125}Te (which is stable) by electron capture, emitting gamma rays and low-energy electrons
Half-life = 60.2 days
Gamma energy = 0.035 MeV
Dose rate from 1 mCi of I-125 in a glass vial:

400 mrem/hr at contact
150 mrem/hr at 1 cm
5 mrem/hr at 10 cm

Tenth-value layer = 0.5 mm Pb

Metabolic Data

^{125}I taken into the body tends to deposit and be retained in the thyroid gland. Essentially all ^{125}I entering either the respiratory or GI tracts is absorbed by body fluids. It is estimated that approximately 30% of this amount is deposited in the thyroid, while the remaining 70% is immediately excreted. Iodine deposited in the thyroid is eliminated with a biological half-life of 120 days.

Assessments of ^{125}I intake are usually made from thyroid scans, although urinalysis can also be used.

The Annual Limit of Intake (ALI) for occupationally exposed persons is 40 microcuries for ingestion and 60 microcuries for inhalation. The ALI is the amount of ^{125}I which, if ingested or inhaled, would result in a dose of 50 rem to the thyroid.

Radiation Monitoring and Protection

Dosimetry should be worn by all personnel working with ^{125}I. In addition, thyroid scans should be performed on personnel who handle millicurie quantities.

Special Handling Precautions

1. ^{125}I emits low-energy, but still penetrating, radiation. Millicurie quantities present an exposure hazard at short range, but reduction by a factor of 100 can be obtained by moving from 1 to 10 cm from a small volume source. Remote handling techniques are advised when handling millicurie amounts in small volumes.

2. A lab coat, impervious gloves and a personnel dosimeter should be worn during all experimental procedures. Work should be performed in a properly functioning, certified fume hood to prevent airborne contamination in the work area.

3. Set up a separate area for ^{125}I work. All work should be performed over plastic or metal trays lined with absorbent paper. Set up shielded areas at the rear of the hood for storage of liquid waste and stock solutions.

4. Iodinations involving 1 mCi amounts or greater shall be performed in a properly functioning, certified fume hood.

5. The RS Office shall monitor the fume hood, work benches, floor, sink, etc., on a monthly or quarterly basis. If contamination levels greater than 200 dpm are found, the user is requested to decontaminate the area, which is then re-tested. Any good detergent solution or EDTA can be used for decontaminating surfaces.

6. Store all ^{125}I waste behind at least 1 mm of lead. The lead will reduce the external radiation level by more than a factor of ten. Small quantities of liquid waste should be labeled and stored in the fume hood.

Chapter 11. How do I...

A. Get Training?

All persons intending to use ionizing radiation must obtain training from the RS Office prior to use. Call the RS Office at extension 4-6879 to set up an appointment. Training can usually be performed on an individual basis as the need arises. Prior to the training session, read the initial training document and the Radiation Safety Manual. All radiation use laboratories should have a copy of the current training document available. The training session takes approximately one hour. It is particularly important that you are familiar with the characteristics of the radiation or radioactive material you intend to use. If you have been previously monitored for occupational exposure to radiation, you may be asked to provide the location and time period when you worked with radioactivity. Even if you have worked with radiation before or have received training at another institution, you must receive training at SDSU prior to using radiation.

B. Amend or Terminate a RUA?

Any proposed change to the conditions specified on the RUA must be submitted in writing to the RS Office. If there is a significant change in the research protocol or procedure specified in the RUA application, an amendment is required. The most common items requiring amendment are adding a radioisotope, changing the approved quantity or changes in use location. If the proposed change is relatively minor and does not involve a change in protocol or the addition of another radioisotope, the amendment process may take only a matter of days. Significant changes in a RUA require approval by the RSC. Advance notice is always helpful to avoid delays to research. Also refer to Chapter 3, Section D.

C. Maintain an Inventory of Radioactive Materials?

A requirement of your RUA is to maintain a current inventory of radioactive materials. As radioactive materials are received in the lab, records of receipt must be kept. Records must contain, at a minimum, the date the shipment was received, the activity ordered and the name of the compound. In addition, as material is used the amount removed must also be noted to keep a running total of the amount of material available. The format for this receipt/use log is up to the PI but must be maintained in a clear and concise manner. The record of use must include the initials of the person removing the material and the activity removed.

D. Estimate the Activity in Radioactive Waste?

The laboratory is responsible for the management of waste prior to pick up by the RS Office. This responsibility includes providing a reasonable estimation of the total activity in the waste container. For liquid waste, a sample of the waste may be taken and counted on a liquid scintillation counter. Using the efficiency of the detector for the radioisotope of interest, the activity of the sample can be calculated using the following formula:

- Counts per minute/Efficiency = Disintegrations per minute (DPM)
- DPM/2.2e+06 DPM/microcurie (uCi) = ? uCi in the sample
- uCi in the sample x (Total container volume/Sample volume) = Total activity (uCi)

Laboratories with good inventory records should be able to infer from the quantity of radioactivity received, the amount used, the amount in liquid waste, what the approximate activity is in the solid waste.

Another acceptable method for estimating the activity in waste is to keep a tally sheet for each waste container. As waste is deposited, an estimate of the activity is recorded. When the container is almost full, the amounts are summed and recorded as the total activity. Although waste should not be intentionally stored for decay in the lab, a decay correction may occasionally be required for short-lived materials. Waste should in no case be stored in the laboratory for over one year.

If the lab performs the same type of procedure over a long period of time, it is reasonable to assume that the activity in the waste will be known from historical data. Keep in mind that if procedures change, the historical data will no longer reflect the actual activity.

Avoid using notations such as "less than" a certain activity. The amount of activity listed on the waste container dictates how the waste is processed. Therefore, it is important that the amount listed be a close approximation.

Never attempt to use a GM counter to quantify the activity in a waste container.

E. Perform Post-Procedure Monitoring?

Contamination control is the responsibility of everyone who uses radioactive materials. Directly after performing a procedure using radioactive material, a survey must be done by laboratory personnel to detect the presence of radioactive contamination. The lab is also responsible for performing decontamination as necessary. It is important that an instrument be used which is appropriate for the type of radiation. Laboratories using ^{32}P, ^{35}S or ^{14}C may use a GM counter for detecting the presence of contamination. Keep in mind that the detection efficiency of a GM counter for low energy beta particles (e.g. ^{14}C and ^{35}S) may be less than 5%. Surveying for these radioisotopes should be supplemented by taking wipes and counting them for loose activity on a liquid scintillation counter (LSC). For labs using ^{3}H, liquid scintillation counting is the only method to check for contamination.

F. Obtain Radioactive Material?

Once a RUA has been signed and posted in your laboratory, the PI or designee may order radioactive material from any source within the limits specified on the RUA. No additional approval is necessary. If radioactive material is received that is not in accordance with the RUA, an amendment will be required before the material will be released to the lab. The vendor should be advised to ship the material to Environmental Health & Safety. The packing list should indicate the name of the PI for prompt delivery to the lab by RS Office personnel.

G. Ship Radioactive Material?

Shipments of radioactive material or potentially contaminated items must conform with Department of Transportation, International Airline Transporters Association (IATA) and other requirements. To ensure that these requirements are met, contact the RS Office so that adequate packaging and documentation can be arranged. Once radioactive material has left the campus it is considered a shipment and must conform with all requirements.

H. Release Equipment Used to Process or Store Radioactive Material?

Any piece of equipment used in conjunction with or to store radioactive material must be surveyed for free release prior to its relocation outside an area approved for radioactivity. If an item is to be sent off campus or repaired outside the laboratory environment, a survey must be done. Any sign indicating that radioactivity may be present must be removed after the survey confirms that no contamination exists. Common examples of this occurrence may be a centrifuge or pipette used with radioactivity or a refrigerator used to store radioactive material. Please contact the RS Office if something in your lab requires free release.

I. Have the Contamination Monitor Calibrated?

The RS Office calibrates all portable contamination monitors as a service to those with active RUAs at no charge. This service includes GM counters and scintillation detectors. All instruments known to the RS Office are on a task list for routine calibration every year. If you notice that the calibration date has lapsed, contact the RS office and the instrument will be picked up and calibrated. In addition to a calibration sticker, documentation of calibration is maintained on file in the RS Office.

J. Get Dosimetry?

SDSU has an obligation to provide personal radiation monitoring devices for occupationally exposed persons having the potential to obtain 10% of the occupational dose limits. If you are intending to use high energy beta emitters such as ^{32}P or any X or gamma radiation, it is your responsibility to notify the RS Office prior to commencing work. In general, dosimetry is issued upon receiving training by the RS Office. In the event that you have received training and have not been issued dosimetry, call the RS Office. An evaluation will be performed of your intended use and the appropriate dosimetry will be issued. Under no circumstances may you perform work with radiation unless the RS Office has issued you dosimetry or determined that dosimetry is not warranted.

K. Get a Replacement for a Lost Dosimeter?

If your radiation dosimetry is lost or damaged, contact the RS Office immediately before continuing work with radiation. A replacement dosimeter will be issued and you will be asked to fill out a form regarding your use of radiation since the lost dosimeter was issued. Your dosimetry record is a permanent legal record of your radiation dose history. It is important for you to keep your record as accurate as possible by reporting lost or damaged dosimetry promptly.

APPENDIX 1

Definitions and Acronyms

Definitions

Absorbed Dose

The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the international unit gray (Gy) or the rad.

Quantity	Name	Symbol	Units	Conversions
Absorbed Dose	gray *rad (old unit)*	Gy *rad*	J Kg^{-1} *100 ergs* $gram^{-1}$	1 Gy = 100 rads 1 cGy = 1 rad

Activation

The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear radiation.

Activity

The rate of disintegration per second (dps), minute (dpm) or decay of radioactive material. The units of activity are the international unit becquerel (Bq) or the curie (Ci).

Quantity	Name	Symbol	Unit	Conversions
Activity	becquerel *curie (old unit)*	Bq *Ci*	dps *3.7* H 10^{10} *Bq*	1 Ci = 3.7 x 10^{10} Bq

Sub units of the curie are:

millicurie (mCi) = 3.7 H 10^{7} dps
microcurie(μCi) = 3.7 H 10^{4} dps
nanocurie (nCi) = 3.7 H 10^{1} dps
picocurie (pCi) = 3.7 H 10^{-2} dps

ALARA

Acronym for **A**s **L**ow **A**s **R**easonably **A**chievable. Making every reasonable effort to maintain exposures to radiation as far below the dose limits as practical and consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations.

Analytical X-ray System

A group of components utilizing x rays to determine the elemental composition or to examine the microstructure of materials.

Bioassay

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

Bremsstrahlung

Photons emitted when charged particles decelerate or change direction when passing through matter.

CDPH-RHB

California Department of Public Health-Radiologic Health Branch, The state's licensing and regulatory agency.

Clean Area

An area within a laboratory that is designated for the consumption and/or storage of food and beverages. A clean area must be clearly separated from any hazardous material use and storage and be specifically approved by RS Office.

Contamination

Deposition of radioactive material in any place where it is not desired.

Controlled Area

A defined work area or laboratory in which occupational exposure of workers to radiation or radioactive material is under the direct control of the university.

Curie

See "Activity."

Diagnostic X-ray System

An x-ray system designed for irradiation of any part of the human or animal body for diagnostic purposes.

Diffraction X-ray System

An x-ray system designed for routine analytical work. The primary beam from the target of the x-ray tube emerges from the machine through a collimator and strikes the sample, which diffracts in a characteristic manner. The diffraction pattern is measured with a photographic film or a radiation detector.

Declared Pregnant Worker

A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception for the purpose of monitoring the radiation dose to the fetus.

Deep Dose Equivalent (DDE)

External whole body exposure that is the dose equivalent at a tissue depth of 1 centimeter (1,000 mg/cm^2).

Dose Equivalent (H)

The product of the absorbed dose (D) in tissue and quality (Q) factor (i.e. H(rem) = D(rad) x Q) or organ dose weighting factors ($w_{T)}$ (i.e. Gy H = Sv) and all the necessary modifying factors at the location of interest. The units of dose equivalent are the international unit sievert (Sv) or the rem.

Quantity	Name	Symbol	Unit	Conversions
Dose Equivalent	Sievert *rem (old unit)*	Sv *rem*	$J\ Kg^{-1}$ *10^{-2} Sv*	100 rem = 1 Sv 1 rem = 1 cSv

Exposure

A measure of the ionization produced in air by x or gamma radiation. The sum of electric charges on all ions of one sign produced in air when all electrons liberated by photons in a volume of air are completely stopped in air, divided by the mass of the air in the volume. The units of exposure in air are the international unit coulomb per kilogram or the roentgen.

Eye Dose Equivalent (LDE)

External exposure of the lens of the eye that is the dose equivalent at a tissue depth of 0.3 centimeters (300 mg/cm^2).

Half-Life, Radioactive

The time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life.

High Radiation Area

Any area accessible to individuals that radiation exists at levels such that an individual could receive, in any one hour, a dose equivalent in excess of 100 millirem (1.0 millisievert) at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Ionizing Radiation

Any electromagnetic or particulate radiation capable of producing ions directly or indirectly in its passage through matter. In general, refers to gamma rays and x-rays, alpha and beta particles, neutrons, protons, high speed electrons and other nuclear particles. Ionizing radiation does not include radiowaves or visible, infrared or ultra-violet light (i.e., non-ionizing radiation).

keV

A thousand electron volts.

LSC

Liquid scintillation counter.

Monitoring

Checking for the presence of sources of radiation under a specific set of conditions. Monitoring includes measuring levels of radiation fields and determining contamination levels. Monitoring is performed both for health protection and for protection of current and future research.

NRC

The Nuclear Regulatory Commission (NRC) is the primary federal agency charged with regulating the use of by-product radioactive and special nuclear materials.

Occupational Dose

Occupational dose means the dose received by an employee:

1. In a restricted area or controlled area or;
2. In the course of employment, education, training or other activities that involved exposure to ionizing radiation.

Personnel Dosimetry

Devices that measure the cumulative dose of radiation exposure to an individual.

Radiation Area

An area accessible to individuals in which radiation exists at such levels that an individual could receive, in any one hour, a dose equivalent to the whole body in excess of 5 mrem (0.05 millisievert) at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Radiation Producing Machine

Any device capable of producing ionizing radiation when the associated control devices are operated, excluding devices that produce radiation only by use of radioactive materials.

Radiation Safety Committee (RSC)

A committee consisting of SDSU faculty and staff which sets policy regarding use of radioactive material at SDSU consistent with the RML.

Radiation Safety Officer (RSO)

The RSO is responsible for operation of the radiation safety program and assuring that use of ionizing radiation is in conformance with University policies and applicable regulations.

Radiation Use Authorization (RUA)

An authorization issued by the RSC to conduct specific research using specific radionuclides or ionizing radiation producing machines.

Radioactive Materials

Any material, solid, liquid or gas, that emits ionizing radiation.

Radiological Safety Index (RSI)

Each RUA is assigned an RSI to determine the radiological risks associated with each approved radioisotope, its quantities and the intended use.

Restricted Area

An area with access limited by radiation to protect individuals from undue risk from exposure to radiation and radioactive material. Any radiation area, high radiation area or airborne radioactivity area shall be considered a restricted area.

Roentgen (R)

The Roentgen is a unit of exposure to ionizing radiation. It is the amount of gamma rays or x-rays required to produce ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions. See "Exposure."

Roentgen Equivalent in Man (rem)

The unit used to express human dose equivalence as a result of exposure to ionizing radiation. The relation of the rem to other dose units depends upon the biological effect of the radiation under consideration.

Shall

Term used in laws, regulations or directives to express what is mandatory.

Shallow Dose Equivalent (SDE)

SDE applies to the external exposure of the skin of the whole body or the skin of an extremity that is taken as the dose equivalent at a tissue depth of 0.007 centimeters (7 mg/cm^2).

Somatic Effects of Radiation

Long term effects of radiation to exposed individuals, such as cancer, as opposed to genetic effects to the next generation. Somatic effects may also apply to subsequent unexposed generations beyond the first generation.

Source Materials

Uranium or thorium or any combination thereof in any physical or chemical form, or ores, that contain by weight 1/20th of 1% (0.05%) or more of uranium, thorium or any combination thereof.

Special Nuclear Materials

Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, or any other material so designated by the Nuclear Regulatory Commission, but not including source material. Any material artificially enriched by any of the foregoing but not including source material.

Survey Meter

Any portable radiation detection instrument designed to determine the presence of radioactive materials and ionizing radiation fields. Survey meters are of two types:

1. Count rate meters that detect only the presence of radioactive material. Under certain conditions, the survey meter's reading may be used to determine the exposure rate from a source of radioactive material.

2. Dose rate meters used to evaluate the intensity of radiation fields in units such as rem per hour, millirem per hour or sievert per hour.

Unrestricted Area

Any area with access neither limited nor contained by the University for the purpose of protecting individuals from exposure to radiation and radioactive materials.

Wipe Test (Sample)

A test (sample) made to determine the presence of removable radioactive contamination on a surface. A piece of soft filter paper, Styrofoam or cotton swab is wiped over 100 square centimeters of area surveyed and counted for radioactivity with an appropriate instrument.

10 CFR 20

Refers to the Code of Federal Regulations, Title 10, Part 20, "Standards for Protection Against Radiation."

17 CCR

Refers to the California Code of Regulations, Title 17, Subchapter 4.0. Radiation, sections 30100-30397.

Because the NRC made an arrangement with the State of California setting up regulations as exacting as Title 10, Chapter 1, an "Agreement State" status was established which allows California to operate under its own guidelines.

APPENDIX 2

Forms

APPENDIX 3

Operational Reminders