MMRI

Molecular Medicine Research Institute

RADIATION SAFETY MANUAL

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I. Introduction

For convenience purposes, in all instances whereas the RSO is for mentioned; the reader should invariably understand that if the RSO is not available, the Alternate RSO would be of service and vice versa.

The Molecular Medicine Research Institute (MMRI) uses radioactive materials and radiation sources for laboratory research. MMRI use of radioactive materials is regulated by the following agencies:

US Nuclear Regulatory Commission (NRC)
State of California, Department of Health Services, Radiologic Health Branch
State of California, Environmental Protection Agency

The Director and Chairman of the Institute, Edward P. Amento, MD is responsible for the overall Institute's Environmental Health and Safety Program.

MMRI possesses a Radioactive Materials License from the State of California, Department of Health Services Radiologic Health Branch that authorizes the Institute to use radioactive materials for a variety of activities in its laboratory. The radioisotope room posts a copy.

The majority of the Institute's regulatory requirements are mandated in Title 17, California Control Regulations.

To comply with its various regulatory commitments, the Institute established and will implement a Health Physics Program that ensures compliance with all local, state, and federal regulations.

Jan Rydzewski, Ph.D. is the Institute's Radiation Safety Officer (RSO) and has the responsibility for providing the administrative and scientific leadership necessary to direct a broad range of programs that assure radiological safety conditions (matters relating to health and radiation use, policies, procedures, facilities) that are maintained at the Institute.

Ajith Welihinda, PhD., is the alternate RSO.

Both Radiation Safety Officers are responsible for supervising operations (assurance to government officials and to staff, including all MMRI affiliates, of type and quantity of radionuclides requested, their proposed use, consultation and surveillance of their safe use and research personnel to adhere to implemented Institute's policies).

II. General Responsibilities for the Use of Radioactive Materials

The radiation safety program applies to all uses of ionizing radiation and radioactive material at the Molecular Medicine Research Institute (MMRI). Its provisions provide for the safe use of radioactive materials and machine produced radiation, and conforms to the codes, guidelines, and safety standards promulgated by government agencies (listed in the Introduction Section). The areas of responsibility for the Radiation Safety Officer, the Alternate Radiation Safety Officer, Principal Investigators, and the Workers, and procedures for the purchase and use of radioisotopes are described in the following sections.

1. Responsibilities of the Radiation Safety Officer (RSO)

A Radiation Safety Officer (RSO) has the duty and responsibility to the licensee to oversee and ensure safe operation of the licensee's R&D program. The items below are not a complete list of requirements. A licensee must comply with the conditions of the license and regulations specified in Title 17, California Code of Regulations (17 CCR), Title 10, Code of Federal Regulations (10 CFR), Part 20, and the U.S. Department of Transportation (DOT).
The RSO has the duty and responsibility to

1. Immediately terminate any condition or activity that is found to be unsafe by the RSO and / or a threat to public health and safety or property.
2. Ensure radiation exposures to personnel are as low as reasonably achievable (ALARA).
3. Follow all applicable parts of 10 CFR Part 20 and dose investigational levels.
4. Ensure up-to-date radiation protection procedures in the daily operation of the licensee's radioactive material program are developed, distributed, and implemented.
5. Ensure possession, use, and storage of licensed material are consistent with the limitations in the license, the regulations, the Sealed Source and Device Registration (SSDR) Certificate(s), and the manufacturer's recommendations and instructions.
6. Ensure individuals installing, relocating, maintaining, or repairing devices containing sealed sources are trained and authorized by the State of California, the U.S. Nuclear Regulatory Commission (NRG) or Agreement State license.
7. Conduct training programs and otherwise instruct personnel in the proper procedures for handling radioactive material prior to use, at periodic intervals (refresher training), and as required by changes in procedures, equipment, regulations, etc.
8. Maintain documentation to demonstrate that individuals are not likely to receive, in one year, a radiation dose in excess of 10% of the allowable limits or that personnel monitoring devices are provided.
9. Ensure when necessary, personnel monitoring devices are used and exchanged at the proper intervals, and records of the results of such monitoring are maintained. The results are given to the employee at least annually.
10. Properly secure licensed material against unauthorized removal.
11. Documentation is maintained to demonstrate, by measurement or calculation, that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual limit for members of the public.

12. Notify the proper authorities of incidents such as loss or theft of licensed material, damage to or malfunction of sealed sources, or fire (emergency phone numbers are kept current).
13. Perform audits of the radiation protection program at least annually and documented.
14. Ensure violations of regulations, license conditions or program weaknesses are identified, effective corrective actions are developed, implemented, and documented.
15. Ensure licensed material is transported in accordance with all applicable NRC, Agreement State and DOT requirements.
16. Dispose of licensed material properly.
17. Maintain appropriate records.
18. Ensure up-to-date license is maintained, amendment and renewal requests are submitted in a timely manner.
19. Provide periodic on-site direct supervision over the implementation of the Radiation Safety Program in technical and administrative issues.
20. Review dose records and surveys are reviewed quarterly to ensure safe operations, adequate staff training and engineering controls and to look for trends.
21. Ensure ALARA practices are being followed.
22. Ensure new users and uses of radioactive material are reviewed prior to first use.

Note: In the event that the licensee proposes a change in its RSO or to terminate the license, you acknowledge and agree to remain the licensee's RSO until RHB amends the license reflecting this change or terminates the license.

2. Responsibilities of the Principal Investigator

Principal Investigators will be approved to use radioactive material according to Section 4 (below): *Procedures for request of Radioisotope Use Approval (RUA)* which includes purchasing, using and supervising the use of radioisotopes. P.I's responsibilities include:

A. Ensure that individuals working under their control are properly supervised and trained to enable safe working habits and prevent exposures to themselves and others and/or contamination of the work areas or environment.

B. Be aware of the potential radiation hazards inherent in a proposed activity; be responsible for instructing personnel in safe practices or directing personnel to sources of information concerning safe practices.

C. Avoid any unnecessary exposure, either to themselves or to other workers.

D. Correct procedures and conditions that may result in the release of radioactive materials and ensure the integrity of containment.

E. Investigate and report in writing to the RSO any problems pertaining to operation and implementation of containment safety procedures, equipment, or areas.

F. Notify the RSO immediately if:

1. Accidental exposure of personnel to ionizing radiation occurs.
2. In case of a spill of radioactive material.
3. Unknown inventory (possible loss) of radioactive material.
4. Of any other matters pertaining to radiation safety.

G. Notify the RSO of any personnel changes, including addition or termination of employees.

H. Notify the RSO if one of their direct reports has lost their radiation dosimeter.

I. Keep current records of the receipt and the disposition of radioactive material in their possession including use in research, waste disposal, transfer, storage, etc.

J. Verify that survey meters are operable and that calibration is current to ensure their use.

3. Responsibilities of the Worker

Individuals who use radioactive materials assume certain responsibilities in their work. The individual worker is the "first line of defense" in protection of people and the environment against undue risks of radiation exposure and/or contamination. Since the workers, themselves, are the direct handlers of the radioactive material, the final responsibility lies with them for safety and compliance with laws and regulation. For this reason, it is critical that they are aware of the risks, safe practices and requirements for use of radioactive materials.

The term "worker" is used by MMRI to identify an individual who uses radioactive material in the course of his/her employment. Workers may be principle investigators, or any individual who will handle radioactive material.

A. Each worker must be approved by the RSO prior to their work with radiation. Workers who want to work independently with radioactive material must be listed specifically on the MMRI license. All others must work directly under the supervision of a person so listed on the MMRI license. Each worker must be initially trained by the RSO after reading the MMRI Radiation Safety Manual. Alternatively, the RSO may certify an employee who can prove they received sufficient training from another source.

B. The worker must attend the annual radiation training course at MMRI.

C. Workers are responsible for adhering to all laws, rules, regulation, license conditions and guidelines pertaining to the use of radioactive materials.

D. Workers must wear their assigned radiation dosimeter during uses of radioactive materials.

E. Workers must practice ALARA (As Low As Reasonably Achievable) in their work, and minimize the potential for exposures, contamination or release of radioactive materials.

F. Radiation work areas must be monitored by the user after each use of radioactive material. If contamination is found, it must be cleaned up.

G. Any abnormal occurrence must be reported immediately to the principle investigator, such as spills, significant contamination, equipment failure, loss of radiation dosimeters and unplanned release.

H. It is the responsibility of the worker to clean any contamination or spills that occur in their work area.

I. Workers are responsible for maintaining security of radioactive material.

J. Workers are responsible for notifying the RSO of termination of employment and returning the radiation dosimeter at the end of their employment.

4. Procedures for Request of Radioisotope Use Approval (RUA)

A. Approval Requirements

1. The RSO will approve requests submitted by Principal Investigators (P.I.)
2. P.I. must meet the following minimum requirements for approval:
    a) Earned a four-year college degree in natural science or related course of study.
    b) Completed a cumulative total of one year of experience using radioisotopes.
    c) Completion of the MMRI's annual radiation safety course or equivalent.
3. P.I. must complete forms [Approval for Use of Radioactive Materials] and [Statement of Training and Experience] and submit to RSO.
4. P.I. must complete the form Investigator's Request for RUA in which details of the radioisotope proposed to be used and the amount to be purchased are specified. This information must be updated when the proposed use changes.

    Note: unless otherwise specified, only those commitments made by the PI must be adhered to. Any changes without prior amendment approval are prohibited.
5. P.I. will provide the RSO with a completed form [Approval for Use of Radioactive Materials] and [Statement of Training and Experience] for each research personnel to be authorized and supervised to use radioactive materials.

B. Purchasing Procedures

1. The P. I. will submit a signed request for the purchase of radioactive material.
2. The RSO will approve and purchase radioisotopes under an MMRI Purchase Order # (P.O.#) and license.
3. The purchase log will be monitored by the RSO or the Alternate RSO according to the governing regulations.

C. Authorization to Use Radioisotopes for Research Personnel

1. All research personnel designated by the P.I. to use radioisotopes must complete the forms: [Approval for Use of Radioactive Materials] and [Statement of Training and Experience]. The forms must be reviewed by the P.I. for completion, then submitted to the RSO prior to the use of radioactive material *(authorization must be obtained before the use of radioisotopes*). (Section D below)
2. When experimental programs change, the radioisotope user will contact the RSO for a new form to assure participation in relevant radiation monitoring programs.

D. Radiation Safety Review

The RSO will:

1. Determine the training level of incoming personnel and acquaint them with Molecular Medicine Research Institute's and all MMRI affiliates requirements for safe radioisotope use.
2. Review each individual's [Approval for Use of Radioactive Materials] and [Statement of Training and Experience]. Upon approval, assign dosimetery.
3. Provide the authorized personnel with a copy of the radiation safety manual.

E. Records

1. RUA forms and accompanying documentation as well as all other forms are kept on file by the RSO per State regulations.
2. Forms are to be updated as amendment requests (*changes in isotope usage*) and approved by the RSO.
3. Purchasing Dept. will maintain copies of all purchase orders as per State Regulations.

F. Forms available from the RSO

1. Principal Investigator's Request for RUA
2. Approval for Use of Radioactive Materials
3. Supplemental Questionnaire
4. Statement of Training and Experience
5. Purchase Request

III. Guidelines for the Use of Radioisotopes

1. General Safety Rules

A. Authorized personnel must wear lab coats, safety glasses, impermeable gloves and their assigned dosimeters while using radioisotopes.

B. Use trays which will hold the contents in the event of spills or breakage of containers during storage or transport between work areas.

C. Lining of trays and working surfaces with absorbent backed paper.

D. All liquid forms of radioactive material must be stored in sealed containers in the radioisotope room.

E. Properly label all containers, storage, and use areas in accordance with 10 CFR 20, Subpart J.

F. Store high energy beta and all gamma emitters in properly shielded containers.

G. Use remote handling tools when appropriate to minimize extremity exposures

H. Use appropriate dosimeters to monitor exposure to radiation

I. Work with radioactive materials in accordance with radiation safety operating and emergency procedures.

J. Monitoring work areas, hands, and clothing whenever there is a possibility of contamination and after each day of use

K. Clean up spills promptly in accordance with written instructions

L. Eating, drinking, smoking and the application of cosmetics is prohibited in the laboratory. Storage of food is prohibited.

M. Never pipet by mouth.

N. Radioactive material will be used only by those approved in the RUA.

O. Appropriate shielding will be used to maintain radiation exposures ALARA.

P. Use the provided and available protective barriers and other shields accordingly.

Q. All materials such as pipettes, pipette tips, tubes, racks, wipes, containers, pans, equipment containing, or which have been used (potentially contaminated) with radioactive material during the experiment must be disposed of as radioactive waste immediately following the conclusion of the experiment. Contaminated equipment should be decontaminated and must be labeled with "Caution Radioactive Material" sign or labeling tape.

R. Never handle doorknobs or other equipment and never walk to other laboratory or non-laboratory areas while conducting a radioactivity experiment.

S. If protective clothing is contaminated, it is mandatory to dispose of it as radioactive waste and to notify the RSO immediately.

T. Wash hands immediately after using radioactive materials.

2. Personal Exposure Monitoring

A. Monitoring

Criteria based on the RUA form.

MMRI personnel are assigned a TLD badge/ring for monitoring as specified by the radiation license. A NAVLAP accredited dosimetry vendor will provide a monitoring service under supervision of the RSO.

1. TLD badges/rings are assigned on a quarterly basis for individuals working with mCi quantities of high-energy beta or gamma emitters. TLD badges will not be assigned to individuals who work with beta emitters with an Emax less than or equal to 167 keV, ie. ^{3}H, ^{14}C.

B. Body Badges/Ring

1. The RSO will distribute and collect TLD badges/rings quarterly.
2. The RSO will investigate an employee dose exceeding MMRI's ALARA limit of $1/10^{th}$ of the quarterly allowable exposure.
3. The occupational dose limits for exposure to ionizing radiation are:

Dose*	Exposed Area
1,250 mrems/quarter	Whole body
12,500 mrems/quarter	Skin of extremities
3,750 mrems/quarter	Lens of the eye

*Based on ¼ of the annual Federal occupational dose limits

3. Laboratory Monitoring for Radioactive Contamination

Each authorized user is responsible for cleaning the laboratory after using radioactive material. Daily monitoring of laboratory benches, equipment, clothing and hands is required to assure that the areas are not contaminated. Monthly laboratory surveys (wipe tests) will be recorded.

A. Survey Methods

Isotope	Principal Emission	Wipe Test Analysis	Report Wipe Tests	Meter Survey	Meter Readout	Probe	Comments
^{3}H	Beta	[1]LSC	DPM	No	N/A	N/A	[1]LSC only
^{14}C	Beta	[1]LSC	DPM	Yes	CPM	Pancake	Poor detection by meter
^{32}P	Beta	[1]LSC	DPM	Yes	CPM, mR/Hr	Pancake, [2]EWGM	EWGM for dose rate
^{33}P	Beta	[1]LSC	DPM	Yes	CPM, mR/Hr	Pancake, [2]EWGM	EWGM for dose rate
^{35}S	Beta	[1]LSC	DPM	Yes	CPM	Pancake	Poor detection by meter

[1] LSC = Liquid Scintillation Counting

[2] EWGM = End Window Probe

B. Daily Monitoring Procedures

1. At the conclusion of each laboratory experiment, personnel using ^{32}P or ^{33}P must monitor their hands, clothing, bench top, floor in front of bench equipment and regular trashcans using the proper survey method as described in the table above.
2. Contaminated skin areas are to be cleaned as described in Section V.
3. Contaminated clothing is to be removed and disposed of as radioactive waste.
4. Contaminated floor, bench, equipment and other items are to be cleaned as described in Section V.
5. Non-removable "Fixed" contamination in excess of three times background must be marked with radiation labeling tape and then brought to the attention of the P.I. who must alert the RSO to evaluate such contamination.
6. Shielding must be devised to reduce radiation exposure levels to 2mR/Hr or less. Plexiglas shielding is to be used for Beta emitters and lead for gamma emitters.

C. Wipe Surveys

1. Frequency

Direct meter surveys (if applicable) and area wipe tests must be performed at the following intervals:

QUANTITIES IN USE*	FREQUENCY
less than 1 mCi (less than 10 mCi ^{3}H, ^{14}C only)	monthly (or after each use if used less than monthly)
1 mCi to 10 mCi (10 mCi to 100 mCi ^{3}H, ^{14}C only)	weekly (or after each use if used less than weekly)
more than 10 mCi (more than 100 mCi ^{3}H, ^{14}C only)	daily (or after each use)

*This refers to stock containers, not what is removed for use.

2. Area diagram

Use the Institute's specific wipe diagram; wipe all areas as designated by number.

3. Beta emitters

a) Wipe Survey:

1) Wipe the designated site of approximately 100 cm^2 in a zigzag pattern with a filter paper or Kimwipe, wetted with an ethanol/water solution. Place the filter paper or Kimwipe into a scintillation vial. Number the vials to correspond to the numbered site. Always include background.
2) Add enough scintillation fluid to cover the filter paper or Kimwipe and mix. Count each sample for at least 1 minute using the appropriate program for the nuclide(s) used.
3) Document the results of the wipe test in the wipe survey log in the radiation folder. Should the results indicate contamination, a decontamination procedure will be conducted immediately. A second count will be done of the area and recorded as well.

4. Records

All report sheets with wipe tests results must be saved in the radiation folder.

5. Routine Monitoring and Wipe Survey Limits

Laboratory surfaces and equipment in the radiation laboratory (Rm 482 a controlled area limited to authorized radioactive material users only) **should be decontaminated to less than 200 dpm/100cm2 as an ALARA goal**. When it is not possible tor practical to get to 200dpm/100cm^2, MMRI will label the equipment or surfaces as radioactive. MMRI will ensure that the contamination amounts do not exceed the contamination levels listed in Table Q.2 Table Q2 in NUREG – 1556, Vol 7, which for

beta-gamma emitters it 1000 dpm/100cm^2. Contact the MMRI RSO for any questions/issues.

6. Release of Equipment into Unrestricted Areas Limits

As an ALARA goal, equipment should be decontaminated to **less than 200 dpm/100cm^2**. When it is not possible or practicable to get to 200 dpm/100cm^2, MMRI will ensure that the amounts do not exceed the contamination to levels listed in Table Q2 in NUREG-1556, Vol 7, which for removable beta-gamma emitters is 1000 dpm/100cm2. Contact the MMRI RSO for any questions/issues.

7. Decontamination of unrestricted areas

If an accident causes radioactive contamination outside of the radiation lab (Rm 482, which is restricted area), contact the MMRI RSO immediately. Contamination found on laboratory surfaces (e.g. bench tops, walls, floor coverings, etc.) in ***unrestricted areas*** should be immediately decontaminated to levels that are indistinguishable from background levels as an ALARA goal. When it is not possible to get to background levels, MMRI will ensure that the amounts do not exceed the contamination levels listed in Table Q.2 Table Q2 in NUREG-1556, Vol7.

IV. Guidelines for Disposal of Radioactive Waste

If you anticipate generating large volumes of waste, please call the RSO before beginning the experiment.

1. Segregation of Wastes

A. MMRI must segregate radioactive waste by the following categories:

1. Liquid Scintillation Waste
2. Dry Waste (Solid Waste)
3. Liquid Waste

2. Waste Disposal

A. Scintillation fluid

1. Well Plates (microbeta plates containing liquid scintillation fluid)
   a) Separate ^{3}H and ^{14}C from short-lived radioisotopes (^{32}P, ^{33}P, ^{35}S).
   b) Collect well plates in plastic boxes labeled with the isotope marked on the box and stored behind appropriate shielding until the pickup by the waste company.
   c) Call the RSO for waste pickup or to answer any questions.

2. Scintillation Vials
   a) Dispose of full vials in the original containers in upright trays.
   b) Separate into 3 waste streams:

1) Low concentration (< 0.05 micro curie/ml) of ^{14}C and ^{3}H

2) Radionuclides with half-life > 90 days (e.g. ^{14}C, ^{3}H)

3) Radionuclides with half-life < 90 days (e.g. ^{32}P, ^{33}P, ^{35}S)

c) Call the RSO for waste pickup or to answer any questions.

3. The City of Sunnyvale Waste-Water Treatment Plant **does not** authorize disposal of non-radioactive and environmentally safe scintillation fluid in the drain.

4. Enter the disposal information (e.g. date, isotope, activity, volume/weight, waste type) into the Radioisotope Disposal Log.

B. Dry Waste

1. Separate short-lived radionuclides (i.e., those with half lives less than 90 days) from long-lived radionuclides in dry waste. Deface any radioactive labels going into the short-lived radionuclides waste box.
2. Do not put dry radioactive waste containers near regular trash containers.
3. Dispose of solid waste in either of the following:
   a) 2 cubic feet dry waste boxes in clear plastic liners. Seal box bottom before adding liner or any waste. Clearly identify the radionuclides and activities contained in each container and seal when full. Use strong tape.
   b) Heavy plastic bags placed in an appropriately shielded secondary container. When full, seal the bag with strong tape, zip-ties or other appropriate material, then double bag and seal again. Clearly identify the radionuclides and activities in the bag.
4. Syringe needles, razor blades, and broken glass
   a) Put in sealed, hard-walled containers (e.g., sharps containers) before placing them in the dry waste.
5. Do not throw hazardous materials (e.g., chemicals, ether cans, biological materials, broken thermometers, etc.), lead pigs or liquids of any kind into solid waste containers. Call the RSO if you have any questions about what can and cannot be disposed of as solid waste.
6. All waste must be labeled with company name and contact person.
7. Call the RSO to request a pick-up, containers, labels, or to answer any questions.
8. Enter the disposal information (e.g. date, isotope, activity, volume/weight, waste type) into the Radioisotope Disposal Log.

D. Liquid Waste

1. All Liquid Waste
   a) Dispose of radioactive liquid waste in a 5-gallon Jerry jug or a 1-gallon plastic bottle. Always use plastic secondary containers to prevent spills. Do not fill jugs higher than the fill line indicated on the jug. Do not place pipette tips, magnetic stirrers or other solids into liquid waste.

b) Store short-lived radionuclides (i.e., those with half lives less than 90 days) separate from long-lived radionuclides in liquid waste.

c) Clearly identify the radionuclide, activity, and chemical composition (by percent) contained in each jug. Remember that aqueous refers to water and that percentages must add up to 100 (e.g., 80% H20, 20% ethanol).

d) Seal the container and attach a completed label.

e) Do not place liquid from a primary vial into a liquid waste jug. The primary vial will be picked up separately.

f) All waste must be labeled with company name and contact person.

g) Call the RSO to request containers, labels, pickup forms or to answer any questions.

h) Enter the disposal information (e.g. date, isotope, activity, volume/weight, waste type) into the Radioisotope Disposal Log.

2. Procedure for Sanitary Sewer Disposal of ^{14}C, ^{3}H, ^{32}P, ^{33}P and ^{35}S:

a) Aqueous solutions of ^{14}C, ^{3}H, ^{32}P ^{33}P and ^{35}S can be disposed only in the sink in Lab 482. Disposal amount cannot not exceed 1000 uCi per month and must be less than 7.35E-06 µCi/mL for each isotope. The sink is surveyed monthly.

b) Before disposal, make sure that the disposal log is updated to show that the total radioactivity allowed per month will not be exceeded by your disposal.

c) Record your name, the date of discharge, the name of the isotope, and the quantity of the discharge in the sink log.

d) Only non-hazardous, aqueous solutions can be sink-disposed.

e) No solution containing chemical or biological materials that is prohibited from the sanitary sewer can be sink-disposed.

f) Disposal must be followed by adequate flushing.

E. Short-Lived Radionuclides (^{33}P, ^{32}P, ^{35}S) DECAY IN STORAGE.

1. Storage Procedure:

Before use, waste containers must be assigned and clearly labeled with a single short-lived isotope and a specific and compatible waste stream (e.g. aqueous liquid, organic liquid, LSC vials, LSC plates, and solid waste). Only the specified waste stream will be added to each container. When the container is filled, it will be assigned a number, sealed and labeled with the date; only then will a new container be started, ensuring that the waste is represented by a well-defined age group with the same half-life.

a) Note that all short-lived radioactive waste must be stored and handled in the same manner as all other radioactive materials at MMRI until determined as non-radioactive. The materials must be stored in an appropriate container with the proper shielding as described in this safety manual. Sufficient shielding must be employed so that when surveyed, less than a 2 mrem dose in any one hour are detected outside of the storage container. All short-lived radioactive waste must be stored the radiation lab Rm 482.

b) Deface any radioactive labels going into the short-lived radioisotope the dry waste box.

c) All waste containers filled with short-lived isotopes must be dated with the final filling date, labeled with the isotope and activity, and sealed or taped so that no additional materials are added after that date.

d) After a period of 10 half lives of the longest-lived isotope in the container or bag (e.g. 253 days for ^{33}P, 143 days for ^{32}P, 875 days for ^{35}S) is surveyed for radioactivity (See section 2). If determined non-radioactive then it can be disposed of as non-radioactive waste.

e) As with all radioactive waste, waste from short-lived radioisotopes must be entered into the Isotope Users Log and Radioisotope Disposal Log.

2. Survey Procedure:

At time of disposal as non-radioactive waste, the following survey procedures must be carried out.

a) Liquid Waste:

Count an aliquot by LSC. The volume is dependant upon the chemical composition of the liquid waste. If no reading distinguishable from background is detected, the solution may be released. Enter the final filling dates noted on the container, the isotope, original activity, and date of release into the Radioisotope Disposal Logs, and then remove all labels from the container. Retain the LSC results in the Disposal Logs.

b) Dry Waste:

1) In a low background area, survey all surfaces of each bag or container.

2) For pure beta (e.g. P-32 and S-35) will be scanned using the GM pancake or equivalent (<2.0 mg/cm2 window). Surveys will include all outer surfaces of each container to be released (i.e., scan within 1 inch of the surface at a scan rate not greater than 1 inch per second).

3) If no readings distinguishable from background are detected, the whole batch may be released. Enter the final filling dates noted on the bag or container, the isotope, original activity, and date of release into the Radioisotope Disposal Logs, and then remove all labels from the bag or container.

3. Disposal Procedure

a) All waste must be labeled with company name and contact person.

b) Call RSO for pickup of waste.

F. Waste Minimization Techniques

1. Use radioisotopes with half-lives less than 90 days.
2. Dry waste contaminated with short-lived radioisotopes is incorporated into our decay-in-storage program, thus reducing the amount of waste requiring disposal at radioactive waste disposal sites. Separate short-lived radioisotopes (half-life less than 90 days) from long-lived radioisotopes in dry waste.

3. Separate short-lived aqueous solutions from long-lived aqueous solutions.
4. Separate organic, toxic, or corrosive solutions from aqueous (i.e., water-based), nontoxic or noncorrosive solutions.
5. Separate scintillation vials with activities less than 0.05 μCi/ml of ^{14}C and/or ^{3}H (i.e., exempt quantities) from other LSC vials.
6. Do not put lead into dry radioactive waste containers. Check it for contamination and decontaminate, if necessary. The waste agency will recycle lead.
7. Call the RSO to answer any questions for more information.

V. Emergency Procedures

1. Notification of the Radiation Safety Officer

The RSO is to be notified **immediately** of any unplanned occurrence involving ionizing radiation. This includes but is not limited to: accidental direct radiation exposure, extensive contamination of floors and work surfaces, or contamination of laboratory personnel.

- ***Jan Rydzewski, RSO:*** (510) 703-4628 (24 hr)
- ***Ajith Welihinda, ARSO:*** (408) 605-9239 (24 hr)

2. Notice to State of California, Dept. of Health Services, Radiologic Health Branch

If the incident exceeds limits set forth in Title 10 CFR part 20, Subpart C (sections 20.1201 through 20.1208), the State Department of Health Services must be notified:

- ***Radiological Health Branch-Sacramento:*** (916) 327-5106 (days)
- ***Office of Emergency Services:*** (800) 852-7550 (24 hours)
- ***Radiological Health Branch-Richmond (Region 4)***
  850 Marina Bay Parkway, Bldg. P, 1st Floor Richmond, CA:
  (510) 620-3416 or (510) 620-3420
- ***Inspection Agency - Radiologic Health Branch North:*** 510-620-3416

3. Management of Radiation Incidents

A. Area contamination (volatile radionuclide or mCi quantity) involving potential health hazard

1. In the event of accidental dispersion of radioactive contamination over a significant area:
   a) Vacate the area, leave behind clothing and other articles that may be contaminated.
   b) Alert and keep all persons out of the area (except for monitoring and rescue teams).
   c) Call the RSO immediately
   d) Do not attempt decontamination except as expressly directed by the RSO or alternate RSO.

B. Minor contamination (μCi) amounts involving no immediate health hazard:

1. Notify everyone in the room and area at once.
2. Monitor personnel before they leave and then change clothes or lab coat, as necessary.
3. Call the RSO for assistance as needed
4. Put on disposable gloves, lab coat, and shoe covers to prevent contamination. Wash your hands first if they are contaminated - following the Radiation Safety Manual procedures for decontamination of the hands and skin.
5. Survey, mark, or block off the contaminated area with warning signs or labels.
6. Use absorbent paper or absorbent material on the spill to limit the spread of contamination. Work from the outside inward to avoid spreading contamination.
7. Have a plastic bag available to deposit contaminated gloves and paper towels, etc. Put all contaminated objects and cleaning materials into containers to prevent spread of contamination.
8. Start decontamination procedures immediately. Normal cleaning agents or commercial decontamination agents should be adequate. Put on shoe covers and begin procedures by using paper towels with the decontamination agent. Scrub from the outermost edges of the contaminated areas and work inward, reducing the area that is contaminated.
9. For strong beta (e.g. ^{32}P) emitters, use minimal direct physical contact of the contaminated area and use Plexiglas shielding whenever possible.
10. In the case of large spills, block off the area. Assign a person equipped with a survey meter and wipe test areas that the meter indicates as being contaminated. Wipe test the areas that were indicated as being clean after decontaminating hot spots.
11. Report the accident to the P.I. and the RSO.

4. Personal Contamination

In the event that persons are contaminated as a result of a radioactivity incident:

A. Administer first aid measures, as necessary.

B. Remove the person from the contaminated area and hold at a transfer point.

C. Report the incident immediately.

D. Flush the contaminated skin area with water and soap using care not to abrade the skin.

E. Refer suspected internal contamination immediately to RSO.

5. Ingestion

Persons swallowing radioactive solutions should be transported immediately to the nearest hospital emergency room (see Section 6 below for location) and treated for poisoning.

6. Injuries

A. Persons cut by glassware, injured by hypodermic needles, etc. should immediately wash the injured part under a strong stream of water.

B. For serious injury, call 9-1-1 or go to the nearest Emergency Facility:

Kaiser Permanente
700 Lawrence Expy
Santa Clara, CA 95051
(408) 236-6400

7. Fire

A. Procedures in Case of Fire

- **Call Fire Department immediately at 9-1-1 and/or pull the closest fire alarm**
- Give the operator:
    - YOUR Name and Phone Number
    - LOCATION OF EMERGENCY
    - NATURE OF EMERGENCY
- Notify MMRI personnel immediately
- Attempt to extinguish or control fire, only if possible and by available means (e.g. fire extinguisher).
- Notify persons in the area and evacuate as instructed or if in danger.

B. After Fire is extinguished

1. Monitor all persons, equipment and area for possible contamination.
2. Notify the RSO
3. Decontaminate all persons and equipment.
4. The P.I. will forward a report of the incident to the Radiation Safety Officer.

VI. Radiation and Pregnancy

1. Policy

MMRI's policy regarding the exposure of expectant women to ionizing radiation is to minimize hazards which ionizing radiation can present to the human fetus or embryo.

MMRI has adopted the following recommendation by the National Council on Radiation Protection and Measurements (NCRP):

"During the entire period, the maximum permissible dose equivalent to the fetus from occupational exposure of the expectant mother should not exceed 0.5 rem..."

"In effect, this implies that such women should be employed only in situations where the annual dose accumulation is unlikely to exceed 2 or 3 rem and is acquired at a more or less steady rate. In such cases, the probability of the dose to a fetus exceeding 0.5 rem before a pregnancy is recognized, is negligible."

2. Program

A. MMRI's general policy relating to radiation exposure is to keep doses as low as practical. When an individual receives a reported dose exceeding $1/10^{th}$ the allowable exposure (see *III. Guidelines for the Use of Radioisotipes, Section 2.B*), the Radiation Safety Officer will investigate the circumstances and work with the individual to reduce further exposure.

B. These doses can be put into perspective by comparing them both the natural background radiation dose and the dose received from a typical diagnostic x-ray. In San Francisco, the average background is approximately 100 mrem per year. The average dose from a full plate chest x-ray is about 45 mrem and the dose from a photofluorographic chest x-ray (mobile TB x-ray unit) is about 500 mrem. Note that all permissible occupational exposures are considered to be in addition to any medical exposures that an individual may receive.

C. If you are actively trying to become pregnant, you should arrange to limit your work around ionizing radiation or radioactive materials until your pregnancy is confirmed and then through the third month. Subsequent exposure to radiation is not as critical but you should be particularly cautious through to term. If you suspect some radiation dose while pregnant, you can call the RSO and we will get an early reading of your film badge/ring. (*In any case, if you have any questions or want further information, please call the RSO*).

VII. Shipping and Receiving Radioactive Material

1. Shipping Procedures (P.I. must obtain form from RSO)

A. MMRI will allow shipping only under certain circumstances and strict control. Shipper must have Shippers Training Certificate.

B. P.I. must receive prior approval from the RSO.

C. Upon receipt of approval, the P.I. will receive requirements documentation as well as procedures to process a shipment of radioactive material.

2. Receiving Procedures

A. All packages will be received by the RSO or alternate RSO at MMRI, and delivered to the MMRI radiation room (Room 482). All radioactive materials shipments will be examined, inventoried, and surveyed for contamination.

B. The packing slip will be attached to the PO# copy and returned to the RSO for inventory recording per State Regulations.

C. A survey can be carried out by personnel trained in survey procedures and has been authorized by the RSO to do so. The survey consists of a wipe test of the outer packaging and source vial, when required by 10 CFR 20.1906.

Wipe Survey Procedure:
The appropriate personal protection and monitoring must be used as described in earlier sections.

1. A wipe survey is carried out by wiping an area of no more than 300 cm^2 of the inner package surface with an absorbent material, using moderate pressure, and measuring the activity on the wiping material.
2. The results of the wipe test must be documented in the wipe survey log in the radiation folder. Should the results indicate contamination, the inner package must be decontaminated to **less than 200 dpm /100 cm^2.** When it is not possible or practical to get to 200 dpm/100cm^2 the package must be labeled as radioactive.

D. Emblems and warning labeling indicating the presence of radioactive materials on shipping package must be defaced prior to disposal.

VIII. Inventory Guidelines

1. Each vial of radioactive material received at MMRI will have an inventory number assigned to it by the RSO.
2. The user will receive an inventory sheet to complete. The inventory sheet must be returned to the RSO upon completion of use of the vial.

IX. Safe Handling Data

Isotope	Half Life	Critical Organ	Shielding Energy Radiation	Energy (Mev)	Beta Range in Air	Shielding
^{3}H	12.3 Years	W.Body	Beta	0.0186	6 mm	None
^{14}C	5730 Years	W.Body	Beta	0.156	24 cm	None
^{32}P	14.3Days	Bone	Beta	1.71	610 cm	Plexiglas, 1 cm
^{33}P	25.4 Days	Bone	Beta	0.248	50 cm	None
^{35}S	87.4 Days	Testis	Beta	0.167	25 cm	None

X. General Information Appendix

1. Current Authorized Isotopes and License Possession limits

Authorization of radionuclides not on this list will require amendment of the radioactive materials license.

ISOTOPE	POSSESSION LIMIT
^{3}H	20 mCi
^{14}C	20 mCi
^{32}P	20 mCi
^{33}P	20 mCi
^{35}S	20 mCi

Note: A copy of MMRI license is posted in the Radioisotope Room.

2. Units of Radioactive Material

THE UNIT OF ACTIVITY IS THE CURIE, AND IS DEFINED AS 1Ci=3.7 X 10e10dps
STANDARD LABELING UNITS

1 curie (Ci) =2.22x10E12 dpm
1 millicurie (mCi) =2.22x10E9 dpm
1 micro curie (μCi) =2.22x10E6 dpm
1 nanocurie (nCi) =2.22x10E3 dpm

INTERNATIONAL UNITS

1 becquerel (Bq) =1 dps
1 megabecquerel (MBq) =10E6 dps

CURIE / BECQUEREL CONVERSION

1 curie (Ci) = 37 gigabecquerel
1 millicurie (mCi) = 37 megabecquerel
1 microcurie (μCi) = 37 kilobecquerel
1 nanocurie (nCi) = 37 becquerel
1 picocurie (pCi) = 37 millibecquerel

3. Unit of Exposure Conversions

REM/SIEVERT CONVERSION (Unit of Dose Equivalent)

1 rem (rem) = 10 millisievert (mSv)
1 millirem (mrem) =10 microsievert (μSv)
1 microrem (μrem) =10 nanosievert (nSv)
100 rem (rem) =1 sievert (Sv)

RAD/GRAY CONVERSION (Unit of Absorbed Dose)

1 kilorad (krad) =10 gray (Gy)
1 rad (rad) = 10 milligray (mGy)
1 millirad (mrad) = 10 microgray (μGy)
100 rad (rad) = 1 gray (Gy)

ROENTGEN/ C / kg CONVERSION (Unit of Exposure in Air)

1 roentgen (R) = 258 microcoulombs/kg (μC/kg)

4. Universal Decay equation

$A = A_o e^{-\lambda t}$
A = activity,
A_o = initial activity
λ = decay constant
t = time
Decay Constant (λ) = $\frac{0.693}{T1/2}$
T1/2 = half-life

5. Activity Calculation

$$DPM = \frac{\text{Net CPM}}{\%\ \text{EFF.}} \qquad \mu Ci = \frac{DPM}{2.22 \times 10e6}$$

where Net CPM = gross CPM *minus* BACKGROUND CPM
%EFF. is the counting efficiency of your LSC or gamma counter for the isotope being counted.

References: NRC, State of California Regulations (10CFR20 and CCR)

^{3}H	Nuclide Safety Data Sheet Hydrogen-3 [Tritium]	^{3}H

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Max.: 18.6 keV; Average: 5.7 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	12.3 years
	Biological $T_{½}$:	10 - 12 days
	Effective $T_{½}$:	10 - 12 days*

* Large liquid intake (3-4 liters/day) reduces effective $T_{½}$ by a factor of 2+; ^{3}H is easily flushed from the body

Specific Activity:	9650 Ci/g [357 TBq/g] max.	
Beta Range:	Air:	6 mm [0.6 cm; 0.25 inches]
	Water:	0.006 mm [0.0006 cm; 3/10,000 inches]
	Solids/Tissue:	Insignificant [No ^{3}H betas pass through the dead layer of skin]

II. RADIOLOGICAL DATA

Radiotoxicity:	Least radiotoxic of all nuclides; CEDE, ingestion or inhalation: Tritiated water: 1.73E-11 Sv/Bq (0.064 mrem/uCi) of ^{3}H intake Organic Compounds: 4.2E-11 Sv/Bq (0.16 mrem/uCi) of ^{3}H intake
Critical Organ:	Body water or tissue
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure - None from weak ^{3}H beta Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the only readily available method to assess intake [for tritium, no intake = no dose] Be sure to provide a urine sample to Radiation Safety for confirmatory bioassay whenever your annual ^{3}H use exceeds 8 mCi. If negative, no further bioassay is required unless use exceeds 100 mCi at one time or 1000 mCi in one year, or after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Liquid Scintillation Counting is the only readily available method for detecting ^{3}H
NOTE: PORTABLE SURVEY METERS WILL NOT DETECT LABORATORY QUANTITIES OF ^{3}H

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many tritium compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.
- While tritiated DNA precursors are considered more toxic that $^{3}H_2O$, they are generally less volatile and hence do not normally present a greater hazard
- The inability of direct-reading instruments to detect tritium and the slight permeability of most material to [tritiated] water & hydrogen [tritium] facilitates undetected spread of contamination. Use extreme care in handling and storage [e.g. sealed double or multiple containment] to avoid contamination, especially with high specific activity compounds.

^{14}C	Nuclide Safety Data Sheet Carbon-14	^{14}C

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Max.: 156 keV; Average: 49 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	5730 years
	Biological $T_{½}$:	12 days
	Effective $T_{½}$:	Bound - 12 days; unbound - 40 days
Specific Activity:	4.46 Ci/g [0.165 TBq/g] max.	
Beta Range:	Air:	24 cm [10 inches]
	Water/Tissue:	0.28 mm [0.012 inches]
	[~1% of ^{14}C betas transmitted through dead skin layer, i.e. 0.007 cm depth]	
	Plastic:	0.25 mm [0.010 inches]

II. RADIOLOGICAL DATA

Radiotoxicity:	0.023 mrem/uCi of $^{14}CO_2$ inhaled; 2.09 mrem/uCi organic compounds inhaled/ingested
Critical Organ:	Fat tissue [most labeled compounds]; bone [some labeled carbonates]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure – None from weak ^{14}C beta Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for ^{14}C, no intake = no dose]
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [~10% efficiency];
Beta Scintillator [~5% efficiency]

Wipe Test: Liquid Scintillation Counting is the best readily available method for counting ^{14}C wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many ^{14}C compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.

^{32}P	Nuclide Safety Data Sheet Phosphorous-32	^{32}P

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 1,710 keV; Average: 695 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	14.29 days
	Biological $T_{½}$:	Bone ~ 1155 days; Whole Body ~ 257 days[1]
	Effective $T_{½}$:	14.29 days
Specific Activity:	286,500 Ci/g [10,600 TBq/g] max.	
Beta Range:	Air:	610 cm [240 inches; 20 feet]
	Water/Tissue:	0.76 cm [0.33 inches]
	Plastic:	0.61 mm [3/8 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[2]:	94.7 mrem/uCi [Lung] & 15.5 mrem/uCi [CEDE] of ^{32}P inhaled 29.9 mrem/uCi [Bone Marrow] & 8.77 mrem/uCi [CEDE] of ^{32}P ingested
Critical Organ:	Bone [soluble ^{32}P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure [unshielded dose rate at 1 mCi ^{32}P vial mouth[3]: approx. 26 rem/hr], Internal Exposure & Contamination

III. SHIELDING

Shield ^{32}P with 3/8 inch Plexiglas and monitor for Bremstrahlung; If Bremstrahlung X-rays detected outside Plexiglas, apply 1/8 to 1/4 inch lead [Pb] shielding outside Plexiglas
The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Wear radiation dosimetry monitoring badges [body & ring] if regularly handling mCi quantities of ^{32}P

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller
Wipe Test: Liquid Scintillation Counting is an acceptable method for counting ^{32}P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake].
- Store ^{32}P (including waste) behind Plexiglas shielding [3/8 inch thick]; survey (with GM meter) to check adequacy of shielding (accessible dose rate < 2 mR/hr; should be background); apply lead [Pb] shielding outside Plexiglas if needed.
- Use 3/8 inch Plexiglas shielding to minimize exposure while handling ^{32}P.
- Use tools [e.g. Beta Blocks] to handle ^{32}P sources and contaminated objects; avoid direct hand contact.
  - Always have a portable survey meter present and turned on when handling ^{32}P.
- ^{32}P is not volatile, even when heated, and can be ignored as an airborne contaminant[4] unless aerosolized.

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[1] NCRP Report No. 65, p.88
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156
[3] Dupont/NEN, Phosphorous-32 Handling Precautions [Boston, MA; NEN Products, 1985]
[4] Bevelacqua, J. Contemporary Health Physics [New York; John Wiley & Sons, 1995], p. 282

^{33}P	Nuclide Safety Data Sheet Phosphorous-33	^{33}P

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 248.5 keV; Average: 76.4 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	25.3 days
	Biological $T_{½}$:	Bone ~ 1155 days; Whole Body ~ 257 days[1]
	Effective $T_{½}$:	25.3 days
Specific Activity:	156,000 Ci/g	[5,780 TBq/g] max.
Beta Range:	Air:	50 cm [~ 20 inches]
	Water/Tissue:	0.06 cm [0.024 inches]
	Plastic:	0.05 cm [0.02 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[2]: 15.6 mrem/uCi [Lung] & 2.32 mrem/uCi [CEDE] of ^{33}P inhaled
1.85 mrem/uCi [Bone Marrow] & 0.92 mrem/uCi [CEDE] of ^{33}P ingested

Critical Organ: Bone [soluble ^{33}P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]

Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption

Radiological Hazard: External Exposure – mCi quantities not considered an external hazard
Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for ^{33}P, no intake = no dose].
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected.
No dosimetry badges needed when working with ^{33}P [beta energy too low to be detected]

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller
Wipe Test: Liquid Scintillation Counting works well for counting ^{33}P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- ^{33}P is not volatile, even when heated, and can be ignored as an airborne contaminant[3] unless aerosolized.

[1] NCRP Report No. 65, p.88
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156
[3] Bevelacqua, J. Contemporary Health Physics [New York; John Wiley & Sons, 1995], p. 282

^{35}S	Nuclide Safety Data Sheet Sulfur-35	^{35}S

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 167.47 keV; Average: 48.8 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	87.44 days
	Biological $T_{½}$:	623 days [unbound ^{35}S]; 90 days [bound ^{35}S]
	Effective $T_{½}$:	44 - 76 days [unbound ^{35}S]
Specific Activity:	42,707 Ci/g [1,580 TBq/g] max.	
Beta Range:	Air:	26 cm [10.2 inches]
	Water/Tissue:	0.32 mm [0.015 inches]
	Plastic:	0.25 mm [0.010 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[1]:	2.48 mrem/uCi [CEDE] of ^{35}S inhaled 0.733 mrem/uCi of ^{35}S ingested
Critical Organ:	Testis
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure – None from weak ^{35}S beta Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for ^{35}S, no intake = no dose]
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [~10% efficiency]
Beta Scintillator [~5% efficiency]

Wipe Test: Liquid Scintillation Counting is the best readily available method for counting ^{35}S wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
  - Many ^{35}S compounds and metabolites are slightly volatile and may create contamination problems if not sealed or otherwise controlled. This occurs particularly when ^{35}S amino acids are thawed, and when they are added to cell culture media and incubated. Therefore vent thawing ^{35}S vials in a hood. Incubators used with ^{35}S will have an activated charcoal trap placed in the incubator. Possibility of volatilization must be taken into account when surveying after use.

[1] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122,156

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.