

“This manual is under review in order to comply with the changes in regulations of the local and states agencies. However, this document will be effective until the new changes are incorporated in the manual”.

**University of Puerto Rico
Medical Sciences Campus (MSC)**

Radiation Safety Manual



AUGUST 2014

University of Puerto Rico, Medical Sciences Campus

Preface

The University of Puerto Rico (UPR), Medical Sciences Campus (MSC) strives to provide a safe and healthful environment for all persons associated with the University, including faculty, staff, students, and visitors. Attainment of this goal requires the cooperation and commitment of all persons involved.

The University emphasizes safety education and training as the primary means of achieving this goal. The Radiation Safety Office is responsible for radiation safety functions within the University, providing training and performing periodic safety inspections. The department chairs, faculty members, and supervisors are directly responsible for maintaining an atmosphere that promotes full compliance with the MSC safety policies and procedures. With regard to radiation safety matters, the Radiation Safety Committee, appointed by the Chancellor of the MSC, establishes radiation safety policies and procedures for the University in accordance with requirements set forth by State and Federal regulatory agencies. Responsibility for overseeing compliance with these policies and procedures rests with the Radiation Safety Officer.

Essential elements of the University's radiation safety program are presented in this Radiation Safety Manual. The radiation safety program has been carefully developed to allow all radiation users to participate in utilizing the unique advantages of radiation sources while meeting all safety standards in an efficient and non-intrusive manner. A good radiation safety philosophy is to maintain all exposures at levels as far below regulatory limits as can reasonably be achieved. The University strongly supports this "As Low As Reasonably Achievable" (ALARA) safety goal. The policies and procedures found in this manual were designed to promote the achievement of this goal, and to comply with 10 CFR 20.1101 (a)(b) "Radiation Protection Programs" and 20.2102 "Records of Radiation Protection Programs".

In this era of increasing concern for occupational safety and for the environment, it is essential that all members of the University community become and remain familiar with their responsibilities for compliance with health and safety regulations, including these radiation safety policies and procedures. Please study the contents of this manual. Know and practice these and all other safety rules. The manual is a practical reference, but users must also have technical knowledge of radiation and some experience in handling radioactive materials.

Thank you for your cooperation:

Annabell C Segarra, Ph. D., Chair, Radiation Safety Committee

Jossian J. Pagán, DrPh(c)MS, CNMT, Radiation Safety Officer

Carlos A Ortiz Reyes, PhD(c), MBA, BS, LATG, Dean of Administration

Emergency Telephone Numbers:

1. FOR ACCIDENTS INVOLVING SERIOUS INJURIES TO PERSONNEL, CALL THE EMERGENCY MEDICAL SERVICE (ASEM):

- Emergency Medical Room: (787) 777-3535 or (787) 777-3708, (787) 281-0570
- Security Control Room MSC: ext. 7911 or (787) 758-2525, ext. 1000 or 1001

When calling 7911, inform the Emergency Medical Service (EMS) dispatcher that the accident involves radioactive material.

The EMS dispatcher will ask the caller several questions. The caller should stay calm, and give as much information as possible on the nature of the accident and the injuries involved. The caller should stay on the line until instructed to hang up.

2. Call the MSC Radiation Protection Office:

- During business hours:
 - (787) 758-2525, ext. 1687, 1688 or (787) 766-3062

3. For Injuries involving employees call the Occupational Health Clinic (OHC);

- During business hours:
 - (787) 758-2525, ext. 2910, 2911 or 2913
- After business hours:
 - (787) 758-2525, ext. 1000 or 1001 (MSC Security Control Room)

4. For injuries involving students call the Student's Medical Services;

- (787) 758-2525, ext. 1215, 1216 or 2258

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Radiation Safety Committee 2016

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Abbreviations Used in This Manual

- **ALARA** - As Low as Reasonably Achievable
- **ALI** - Annual Limit on Intake
- **AU** - Authorized User
- **Ci** - Curie
- **cm²** - square centimeters
- **cpm** - counts per minute
- **DAC** - Derived Air Concentration
- **dpm** - disintegrations per minute
- **GM** - Geiger-Muller
- **NaI** - Sodium Iodide
- **kg** - kilogram
- **lfm** - linear feet per minute
- **LSC** - Liquid Scintillation Counter
- **mCi** - milliCurie
- **ml** - milliliters
- **MeV** - mega electron-volts
- **mrem** - millirem (0.001 rem)
- **MSC** – Medical Sciences Campus
- **NRC** - Nuclear Regulatory Commission
- **OHC** - Occupational Health Clinic
- **OLSR – Office of Laboratory Safety in Research**
- **PSA** - Physical Security Activity
- **RIA** - Radioimmunoassay
- **RSC** - Radiation Safety Committee
- **RSO** - Radiation Safety Officer
- **TLD** - Thermoluminescent Dosimeter
- **³H** - Tritium (hydrogen-3)
- **¹⁴C** - Carbon-14
- **³²P** - Phosphorous-32
- **³³P** - Phosphorous-33
- **³⁵S** - Sulfur-35
- **⁵¹Cr** - Chromium-51
- **⁶⁰Co** - Cobalt-60
- **¹²⁵I** - Iodine-125
- **¹²⁹I** - Iodine-129
- **¹³¹I** - Iodine-131
- **¹³⁷Cs** - Cesium-137
- **10 CFR 19** - NRC's Title 10, Chapter 1, Code of Federal Regulations, Part 19
- **10 CFR 20** - NRC's Title 10, Chapter 1, Code of Federal Regulations, Part 20

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Part 1: RADIATION SAFETY PROGRAM

I. FEDERAL REGULATIONS

A. Licenses

The Medical Science Campus, University of Puerto Rico (MSC) operates under one specific license issued by the United States Nuclear Regulatory Commission (NRC), license number 52-01946-07. It must comply with the terms of the license while using any radioisotopes that are produced as by-product materials in a nuclear reactor. The license confers authority upon the University to approve, manage and control the receipt, use and disposal of radioactive materials.

There is only one license for the entire university. For this reason, a violation to NRC regulations by any individual jeopardizes the permission of all authorized users to utilize radioactive material at the MSC. If, for any reason, the license is suspended or terminated, no individual or principal investigator may use licensed radioactive materials until the license is reinstated. Therefore, this license places significant responsibility on each individual who uses radioactive materials to conform to safe work practices, and to conduct and complete all required compliance duties, however large or small they may be.

B. Regulations

The U.S. Nuclear Regulatory Commission (NRC) is the branch of the federal government which regulates the licensing, use and disposal of radioactive materials. A multitude of laws set forth by the NRC must be obeyed. If any of the regulating agencies or authorities determine that the laws or conditions are not complied with during the periodic inspections which they conduct, violations will be cited, and penalties may be imposed. Penalties may include civil penalties (which may be fines or criminal prosecution in court), sanctions, suspension or termination of the license. For this reason, it is imperative that all Authorized Users, workers and support staff involved in the receipt, use, disposal or records of radioactive materials be aware of and comply with these laws.

The Code of Federal Regulations (CFR), Title 10, Parts 19 "Notices, Instructions and Reports to Workers: Inspection and Investigations" and Part 20 "Standards for Protection Against Radiation", are legal requirements set forth for all radioactive materials licensees. In particular, Part 20 contains the general practices, requirements and conditions by which all users of radioactive materials must abide. On January 1, 1994, the revised Title 10 CFR, Part 20 became law for all licensees. Numerous changes were made; most of these changes pertain to the way the programs and operations are managed. The RSO and RSC have the responsibility of assuring compliance with these regulations. NRC now requires from each licensee the practice of ALARA "As Low As Reasonably Achievable". These regulations may be viewed via the Internet at <http://www.nrc.gov/NRC/CFR/index.html>. Additional requirements are included in

the NRC license issued to the MSC governing the possession and use of radioisotopes. Employees are encouraged to refer to these standards and the current license.

II. PROGRAM OPERATIONS

A. Individuals Responsible for Radiation Safety Program

Qualified individuals of the UPR- Medical Sciences Campus as authorize users by the Radiation Safety Committee (RSC) and engaged as principal investigators and/or have significant responsibility for administrative, medical, academic or experimental functions involving radioisotopes and can demonstrate an acceptable level of confidence in the safe handling of radioactive materials.

1. Duties of the Chancellor of the UPR-MS:

- a. Executive management Representative has the authority to make prompt decisions on the basis of the information available with out having to consult with higher management officials.
- b. Have authority to appropriate funds in a timely manner for the radiation safety program significant financial needs.
- c. Designated representative will be available to the RSO and RSC chairperson to facilitate in a effective and immediate action on behalf of management or the RSO and RSC in the event of radiation safety emergency or potential emergency.
- d. Radiation safety, security and control of radioactive materials, and compliance with regulations
- e. Completeness and accuracy of the radiation safety records and all information provided to NRC
- f. Knowledge about the contents of the license and application
- g. Compliance with current NRC and Department of Transportation (DOT) regulations and the licensee's operating and emergency procedures.
- h. Commitment to provide adequate resources (including space, equipment, personnel, time, and, if needed, contractors) to the radiation protection program to ensure that patients, the public and workers are protected from radiation hazards and meticulous compliance with regulations is maintained
- i. Selects an executive management representative to the RSC with a science background or an aptitude for radiation safety issues.
- j. Appoint a representative who actively participates as a member of the radiation safety committee (RSC) and has the authority to delegate necessary resources to the radiation safety program, as identified by the RSC.
- k. Selection and assignment of a qualified individual to serve as the Radiation Safety Officer (RSO) with responsibility for the overall radiation safety program.
- l. Prohibition against discrimination of employees engaged in protected activities

- m. Commitment to provide information to employees regarding the employee protection and deliberate misconduct provisions in 10 CFR 30.7 and 10 CFR 30.10, respectively.
- n. Obtaining NRC's prior written consent before transferring control of the license.
- o. Notifying appropriate NRC regional administrator in writing, immediately following filing of petition for voluntary or involuntary bankruptcy

2. Duties of the Radiation Safety Committee (RSC):

The Radiation Safety Committee (RSC) has the responsibility of establishing a Radiation Safety Program that ensures the safe use, management, storage and disposal of radioactive material in areas under the control of the University of Puerto Rico Medical Sciences Campus (UPR, MSC). This includes the Dr. Guillermo Arbona Building (Main Campus at the Medical Center), Nuclear Medicine Laboratory at Dr. Isaac González Martínez Hospital, the UPR Hospital of Carolina Dr. Federico Trilla, the Institute of Neurobiology at San Juan and the Radiation Protection Office at the Cancer Comprehensive Center. The RSC must ensure compliance with Federal regulations, including those of the U.S. Nuclear Regulatory Commission (NRC) as well as safeguard the environment.

The RSC, as required by NRC regulations and by conditions of UPR MSC Broad Scope License, maintains oversight of all operations involving radioactive materials and radiation-producing equipment. The RSC and the RSO advise the Administration on matters relating to radiation safety and compliance with NRC regulations. The RSC is appointed by the Chancellor of UPR MSC. The duties, membership and organization of the RSC are provided below.

- a. Ensures the safe use and security of all radioactive materials and sources of radiation throughout UPR MSC.
- b. Develops and recommends policies to the Chancellor and Administration for the control and safe use of radiation sources and that ensure compliance with NRC regulations.
- c. Reports concerns about the policies and management of the Radiation Safety Program to the Chancellor.
- d. Reports concerns about procedures and daily operations of the Radiation Safety Program to the Chancellor.
- e. Provides technical oversight, advice, and assistance to the Administration and Office of Radiation Safety on matters concerning radiation safety and security.
- f. Receives, reviews, and acts on all applications for the use of radioactive material or radiation sources in any area used by UPR MSC personnel.
- g. Determines that all activities involving radioactive materials and sources of radiation are being conducted safely and in accordance with applicable federal regulations

and with those established by UPR, MSC concerning radiation safety and security policies.

- h. Receives and reviews periodic reports from the RSO concerning inspections of laboratories and clinical areas where radioactive material are used, monitoring of personnel, and other related radiation safety matters.
- i. Reviews and assesses, as necessary, the overall use of radionuclides and radiation sources used at the UPR MSC for possible modification of possession limits.
- j. Investigates all instances of alleged infractions of safety rules and security regulations to NRC or UPR MSC regulations and determines the course of corrective action(s) to be taken.
- k. The RSC chairperson have access to and direct line of communication with executive management to discuss radiation safety issues that need to be brought to management's attention.
- l. Review and approve each proposal for the use of radionuclides in clinical, in vitro or experiments in animals in order to ensure that procedures employed satisfy established regulations.
- m. Determine whether each physician, scientist user or researcher meets the criteria for minimum basic and clinical (if applicable experience as set forth in Training and Experience requirements - 10 CFR - Part 35.
- n. Perform a quarterly review of occupational radiation exposures with particular attention to instances where Investigational Levels of the ALARA Program are exceeded.
- o. Review the entire radiation safety program at least annually to determine that all activities are being conducted safely and in accordance with the NRC regulations and the conditions of the license. The review shall include an examination of all records, reports from the Radiation Safety Officer, the results of NRC inspection, written safety procedures, and the adequacy of the institution's management control system.
- p. Recommend remedial action to correct any deficiencies identified in the radiation safety program.
- q. Establish guidelines for quality and radiochemical purity of all radiopharmaceuticals administered to human subjects. Review records of quality assurance kept by individual users.
- r. Establish guidelines for performance of instruments used for the measurement of radiation, including survey instruments, area monitors and clinical instrumentation such as scanners, computers and gamma cameras.
- s. Review and approve training programs for persons planning to handle radionuclides in the laboratory or clinic.
- t. Ensure that all radiation workers and persons whose duties require them to work or frequent areas where radioactive material are used, are sufficiently instructed as required in 10 CFR – 19.12.
- u. Meet at least quarterly and as often as necessary to conduct its business promptly. Written minutes are kept and copies are submitted to the Chancellor for information.

3. Membership and Organization of the RSC:

The Radiation Safety Committee shall be appointed by the Chancellor of UPR MSC. The RSC shall include: (1) the Radiation Safety Officer; (2) the Chair of the RSC and (3) a representative from the Administration. Additional members will consist of Authorized Users and of radiation workers such as nurses, nuclear medicine technicians and occupational health employees. The Committee shall have members with expertise on clinical use of radioactivity as well as members that conduct biomedical research with radionuclides. Members shall represent the various types of uses of radioactive materials or radiation sources throughout the UPR MSC. The Chancellor of UPR MSC may at her/his discretion, remove or reappoint any member of the RSC at any time. The RSC may recommend to the Chancellor the appointment of additional members to improve the effectiveness of the RSC. Ex-officio members may also be appointed by the Chancellor or the RSC Chairperson, as needed.

The Chairperson calls and presides over all meetings, establishes agendas, maintains close communication with the RSO, the Radiation Safety Office and the Administration. He/she will inform the Chancellor of important matters pertaining to the Radiation Safety Program. The Chairperson also establishes working groups and appoints ex-officio members to the Committee, as the Committee deems necessary. During a leave of absence, the Chancellor will nominate a member of the RSC to serve as interim Chairperson of the RSC.

The Administrative assistant records minutes of all meetings and maintains official RSC files. The Administration shall provide administrative support to the Committee. Meetings shall be conducted at least four times a year at three month intervals. A quorum will be satisfied with half the members plus one, including the chairperson and the RSO or Deputy RSO (his designee).

4. *Radiation Safety Officer (RSO):*

The RSO is a professional and a qualified individual assigned by the Chancellor of the UPR-MSC to serve as the Radiation Safety Officer (RSO) with responsibility for the overall radiation safety program. The RSO has full access to all activities involving the use of byproduct material and the authority to terminate any activity in which health and safety appear to be compromised without consulting with the Administration Representatives or the RSC, if required. He or she must have sufficient time and commitment from management to fulfill certain duties and responsibilities to ensure that radioactive materials are used in a safe manner.

The RSO manages the day-to-day operations of the Radiation Safety Program, and assures compliance with the policies of the UPR, MSC and with the rules and regulations of the NRC. The duties of the RSO include:

- a. Consulting with members of the RSC and users of the radioactive materials on all matters relating to the use of radioactive materials.
- b. Assuring compliance with the regulations and rules of the NRC and the UPR MSC broad scope license to procure, use, store, secure, and dispose of radioactive materials through monitoring and periodic formal and unannounced inspections.
- c. Developing and implementing procedures for periodic radiological surveys of laboratories; monitoring of personnel; handling and disposal of radioactive wastes; ordering, receiving, and distribution of radioactive materials; and use of sealed radioactive sources.
- d. Developing and implementing training for all personnel involved in any facet of operation involving radioactive materials. Assuring that all UPR, MSC personnel receive periodic review of important procedures, rules, and methods.
- e. Reviewing applications of new Authorized Users and protocols from existing Authorized Users before submission to the RSC.
- f. Maintaining records of procurement, area monitoring, personnel monitoring, accidents and incidents, inventories, and any other documents required by the Radiation Safety Program and NRC regulations.
- g. Approving requests to purchase radioactive materials. The RSO will make certain that only Authorized Users or their approved alternates place orders and will verify that these orders do not exceed established limits under UPR MSC license.
- h. Responding to all emergencies involving radioactive materials and providing expert advice and assistance as required by the program.
- i. Providing guidance to the Occupational Health Clinic on all matters relating to employee exposure to radiation, and monitoring results, etc.
- j. Interacting with the NRC on issues related to the UPR MSC licenses, license amendments, application renewals, and inspections.
- k. Assuring compliance with all "As Low As Reasonably Achievable" (ALARA) regulations as defined by 10 CFR 20.

In an emergency, a designee of the RSO or of the Chair of the RSC may act for the RSO or Chair of the RSC when necessary to control or prevent an incident involving radioactive materials, including the temporary ordering of cessation of laboratory operations or withholding authority to purchase or use isotopes until the RSC reviews these infractions. The RSO and the RSC shall be provided with sufficient authority, organizational freedom, and management prerogative to accomplish these goals. These responsibilities and authorities are limited to those served under NRC license num. 52-01946-07.

The Radiation Safety Office is now part of the Office of Laboratory Safety in Research (OSLI. This Office has the overall responsibility to oversee the safe use of biological,

chemical and radioactive material in biomedical research laboratories of the Medical Sciences Campus of the University of Puerto Rico. Currently the RSO also serves as the Director of the Office of Laboratory Safety in Research. The Director of OLSR reports to the Chancellor, the Dean of Administration and the Chairpersons of the Radiation Safety Committee (RSC) and the Institutional Biosafety Committee (IBC).

B. PHYSICAL SECURITY OF RADIOACTIVE MATERIALS

The Rule: All radioactive material received at the MSC must be secured or under constant surveillance at all times. Shipments of radioactive materials which have not been delivered must be secured at the receiving site by personnel trained by Radiation Safety Office until delivery can be made. Delivery personnel are prohibited from delivering a package with radioactive materials unless there is an Authorized person (Authorized User, Alternate Authorized User, or Radiation Worker) at the location who will accept it, sign for its receipt, and secure the radioactive materials. Shipments of radioactive materials must not be left unsecured in corridors. If it is necessary to deliver the package to an office, the authorized person receiving the shipment must immediately secure the package in a laboratory or storage room designated for work with radioactive materials. If the delivery person cannot find an authorized person to receive the shipment, the package must be taken to the Radiation Safety Office where it will be secured until delivery can be completed. Radioactive materials are not to be left unsecured at any time.

Any radioactive material in use in a laboratory must be attended at ALL TIMES, or secured by locking the laboratory when not attended. Radioactive materials may not be left unsecured even momentarily. Radioactive materials in storage, not being used, must be secured when the room in which it is stored is unoccupied. The required security may be accomplished by locking the room while unoccupied, or alternatively, by locking the radioactive materials within refrigerators, freezers, cabinets, or lock boxes. Wherever possible, lock boxes are recommended for storage of radioactive materials. Only authorized persons may have access to radioactive materials. Radioactive materials that are stored or used in areas common to both authorized and unauthorized personnel must be secured at all times from unauthorized personnel. It is strongly recommended that all laboratories containing radioactive materials be locked when unoccupied during daytime hours and at night.

Corridors (hallways, elevator lobbies, and utility chases, etc.) are not secured areas. Therefore, the use and storage of radioactive materials in these areas are prohibited.

All radioactive wastes are considered as radioactive materials. Radioactive wastes, including dry waste, liquid waste, medical pathological waste, and mixed waste, must be secured at all times. Radioactive waste may be placed in lockable containers. Recommendations may be obtained from the Radiation Safety Office.

Unescorted unauthorized personnel may not enter into a laboratory if an authorized person is not present. Any persons admitted into the laboratory must be accompanied at all times by an authorized person who works in the area. Persons performing work in the area, such as engineering or maintenance personnel, contractors (i.e. janitorial staff, telephone, or computer support personnel) or commercial service representatives must also be accompanied by an authorized person at all times. Persons unknown to the occupants of an area where radioactive materials are used or stored should not be permitted into the area without proper identification and a legitimate reason for entry.

Sanctions for violations of MSC 'S Radiation Safety Policy : Failure to adhere to the rules for proper usage of radioactive materials can result in sanctions against the Authorized User or Radiation Worker. A description of these sanctions follows:

- **Level I Sanction:** This sanction will be for violations that appear to be inadvertent or occasional lapses that are discovered by MSC inspection teams. The Authorized User or Radiation Worker must provide the RSC and RSO a written explanation for the failure and their corrective actions to prevent future failures.
- **Level II Sanction:** This sanction will be invoked for a serious violation or repeated violations that appear to indicate a lack of regard for NRC and MSC radiation safety regulations. This sanction involves a suspension of the Authorized User's or Radiation Worker's access to radioactive material for a minimum of 60 days. All radioactive materials will be confiscated and the Authorized User/Radiation Worker will be required to retake the radiation safety training course, as well as reapply for permission to use radioactive materials. The RSC may also recommend that the MSC administration take additional disciplinary actions against the Authorized User and/or Radiation Worker.
- **Level III Sanction:** This sanction will be imposed for flagrant violations or those that intentionally set coworkers at risk of injury from radioactive materials. This sanction results in permanent revocation of the use of radioactive materials. The RSC may also recommend that the MSC Administration exert additional disciplinary actions against the Authorized User and/or Radiation Worker.

▪ **"AS LOW AS REASONABLY ACHIEVABLE" (ALARA) PHILOSOPHY**

ALARA is an acronym meaning **As Low As Reasonably Achievable**. It is a requirement in the law, meaning all facilities possessing radioactive materials licenses must have a formal ALARA program. It may be defined as a professional standard of excellence, and is practiced by keeping all doses, releases, contamination and other risks as low as reasonably achievable. The regulatory guideline requires managing programs and procedures to achieve 10% of applicable legal limits, such as air and water release limits, exposure limits or contamination limits for radiation use facilities.

It is not a violation of the law to exceed an ALARA guideline; however, these occurrences alert the radiation safety officer and radioactive materials users to situations which need to be reviewed to determine whether the practices may be modified to better reflect ALARA management practices. Practical measures to incorporate ALARA into work routine are included in this manual to assist radiation workers. Some simple concepts and easy precautions may prevent contamination, exposures and releases.

Our ALARA program depends on the cooperation of all users of radionuclides at the MSC. The program includes the use of proper equipment and procedures to lower radiation exposure. The RSO will investigate any whole-body dose in excess of 125 millirems (mrem) or 1,875 mrem to the extremities to any individual in any one quarter. If any worker receives a whole-body dose in excess of 375 mrem or 5,625 mrem to the extremities per quarter, direct actions will be taken to minimize any future exposures. These actions may require a change in laboratory procedure or an increased application of the principles of personnel protection.

D. INVESTIGATIONAL LEVELS IN ORDER TO MONITOR INDIVIDUAL OCCUPATIONAL EXTERNAL RADIATION EXPOSURES:

This institution hereby establishes Investigational Levels for occupational external radiation exposure. If these levels are exceeded, an investigation by the Radiation Safety Committee and/or the RSO will ensue.

These levels apply to the exposure of individual workers.

Table 1. Investigational Levels (mrems)

ORGANS	For a given quarter		Cumulative for the year	
	LEVEL I mRem	LEVEL II mRem	LEVEL I mRem	LEVEL II mRem
Whole body deep (total effective dose equivalent)	125	375	500	1,500
Individual organs - except lens (sum of deep dose equivalent and committed dose equivalent)Whole body shallow	1,250	3,750	5,000	15,000
Lens eyes	375	1,125	1,500	4,500
Skin or extremity	1,250	3,750	5,000	15,000
Hands and forearms; feet and ankles	1,875	5,625	7,500	22,500
Skin of whole body	750	2,250	3,000	9,000
Organs	1,250	3,750	5,000	15,000

*Note: Investigational levels I and II are one tenth and three tenths, respectively, of the applicable regulatory limits.

The Radiation Safety Officer will review and record on NRC-5 form, "Occupational Exposure Record for a Monitoring Period," or on an equivalent form (e.g., dosimeter processor's report), results of personnel monitoring at least once in any calendar quarter as required by section 20.2102 of 10 CFR Part 20. In the event that personnel are found that have exceeded this limit, the following actions will be taken:

1. Personal dose to less than Investigational Level I:
 - a) No action will be taken in cases where an individual's exposure is less than Table 1 values for the Investigational Level I.
2. Personal dose equal to or greater than Investigational Level I, but less than Investigational Level II:

- a) The RSO will review the exposure of each individual whose quarterly exposures equal or exceeds Investigational Level I and will report the results of the reviews at the first Radiation Safety Committee meeting following the quarter when the exposure was recorded. If the exposure does not equal or exceed Investigational Level II, no action related specifically to the exposure is required unless deemed appropriate by the Committee. The Committee will, however, consider each such exposure in comparison with those of others performing similar tasks as an index of ALARA program quality and will record the review in the Committee minutes.
- 3. Personal dose equal to or greater than Investigational Level II:
 - a) The RSO will investigate in a timely manner the cause(s) of all personnel exposures equaling or exceeding Investigational Level II and, if warranted, will take action. A report of the investigation, actions taken, if any, and a copy of the individual's Form NRC-5 or its equivalent will be presented to the Radiation Safety Committee at the first Radiation Safety Committee meeting following completion of the investigation. The details of these reports will be recorded in the Radiation Safety Committee minutes. Committee minutes will be sent to the management of this institution for review. The minutes, containing details of the investigation, will be made available to NRC/State inspectors for review at the time of the next inspection.
- 4. Reestablishment of an individual occupational worker's Investigational Level to a level above that listed in Table 1:
 - a) In cases where a worker's or a group of workers' exposure need to exceed an Investigational Level, a new, higher Investigational Level may be established on the basis that it is consistent with good ALARA practices for that individual or group. Justification for new Investigational Levels will be documented. The Radiation Safety Committee will review the justification, and must approve or disapprove, all revisions of Investigational Levels.

External Radiation Exposure and Protection

The body may be irradiated in two general ways: externally from radioactive material or radiation sources, or internally from radioactive material deposited in the body. External doses can be the result of exposure to gamma, X-ray, or high energy beta emitters. Low energy beta and alpha emitters lack the energy needed to penetrate the outer layer of skin and subsequently present less of an external hazard; they are of more concern when ingested. The external dose an individual receives depends on the following factors: exposure, time, distance, and shielding.

Radiation dose rate is the radiation dose delivered per unit of time. The unit of radiation dose rate is usually rem/hour, mrem/hour, or μ rem/hour. To eliminate or reduce radiation exposure, one must reduce the dose rate or the time spent near a source of radiation. Three primary means of eliminating or reducing radiation exposures exist. They include:

1. **Exposure:** The "strength" (activity, mR/hr, etc.) of the radiation source. By reducing the amount of radioactive material used (lowering the current settings on a radiation producing machine) dose can be reduced.
2. **Maximize the distance from the source:** The dose rate for most gamma and x-radiation varies with the inverse square of the distance from a "point" source. Therefore, the farther you position yourself for the source of radiation, the smaller the dose you receive. Mathematically, $I_2/I_1 = r_1^2/r_2^2$. This is called the inverse square law. For example, if the dose rate is 100 mrem/hour at 5 cm from a point source, you can calculate the dose rate at 20 cm from the source:

$$I_{20\text{cm}}/I_{5\text{cm}} = (5\text{cm})^2/(20\text{cm})^2$$

$$I_{20\text{cm}} = (100 \text{ mrem/hr}) \times (5\text{cm})^2/(20\text{cm})^2$$

$$I_{20\text{cm}} = 6.25 \text{ mrem/hr}$$

For example, doubling the distance from a radiation source will result in 1/4 the exposure in the same amount of time. One practical implementation of this principle is using remote handling devices such as forceps, tongs, and tube racks, etc. to minimize direct contact with sources and containers. Even a small increase in distance can result in a dramatic decrease in dose rate.

3. **Minimize time of exposure:** The less time you remain in a radiation field, the smaller the dose you receive. Perform the experiment or the procedure as quickly and as efficiently as possible without increasing the probability of a spill or other accident.
4. **Shield the radiation source:** If the radiation source is a high energy beta or gamma emitter, shielding will reduce the dose rate. For beta emitters, use a low atomic number material such as plastic, Lucite, Plexiglas, and glass. For gamma emitters, high atomic number materials such as steel or lead are preferred (lead is also a toxic material, so use gloves when handling it, and wash your hands when you finish).

Place shielding between yourself and a source of penetrating radiation to decrease your dose. For low energy beta emitters: (^3H , ^{14}C , ^{33}P , and ^{35}S) shielding is not necessary. For high energy beta emitters (^{32}P), 3/8" acrylic is the shielding material of choice. Does not use lead with high energy beta radiation (e.g. ^{32}P) because it will cause secondary radiation of a more penetrating X-ray type radiation. For gamma or x-ray emitters (^{51}Cr and ^{125}I) lead is used when exposure rates are significant.

Use shielding wherever it is necessary to reduce or eliminate exposure. By placing an appropriate shield between the radioactive source and the worker, radiation is attenuated and exposure may be completely eliminated or reduced to an acceptable level. The type and amount of shielding needed to achieve a safe working level varies with the type and quantity of radioactive material used.

Internal Exposure Protection:

Internal exposure results from the absorption, ingestion or inhalation of radioactive material. This material can be incorporated in the body in several ways: (1) by breathing radioactive gases, vapors or dust; (2) by consuming radioactive material transferred from contaminated

hands, tobacco products, food or drink; (3) by entering through a wound; and (4) by absorption through the skin.

The fundamental objectives of radiation protection measures are: (1) to limit entry of radionuclides into the human body (via ingestion, inhalation, absorption, or through open wounds) to quantities as low as reasonably achievable and always within the established limits; and (2) to limit exposure to external radiation to levels that the established dose limits are below and as low as reasonably achievable.

1. **Inhalation:** A chemical fume hood certified for radioactive material work is highly recommended when using potentially volatile compounds. Certain equipment, such as centrifuges, vortex mixers, and shakers are capable of generating radioactive aerosols. Use in such a way that production of and exposure to radioactive aerosols is minimized.
2. **Puncture:** Dispose of syringes and pipettes promptly and in appropriate containers. Guard against glass breakage and puncture injury during use and disposal. Do not attempt to recap needles before disposal.
3. **Ingestion:** NEVER introduce any food or drink into a posted restricted area, even for temporary storage. DO NOT eat or drink in any area where radionuclides are used, never pipette by mouth, and never store food and drinks in a cold room or refrigerator that is designated for radioactive material storage.
4. **Absorption:** Use measures that prevent the contamination of skin and eyes. If there is any possibility that the clothes have been contaminated, remove this clothing before leaving the lab. Eye protection, (e.g. goggles, face shield) is encouraged to prevent contamination of the eyes. This is particularly important for individuals wearing contact lenses since some lenses will absorb and concentrate radiochemicals. Wear protective gloves at all times when working with radioactive materials. Change gloves frequently during the work, disposing of the used gloves as radioactive waste. Wash hands after using radioactive materials and monitor the hands for contamination, especially before eating or smoking, and prior to leaving the laboratory.

▪ **AUTHORIZED USERS**

All work involving radioactive material must be conducted under the auspices of an approved Authorized User. Each Authorized User is ultimately responsible for the safety of those who use radioisotopes under his/her supervision. To become an Authorized User, one must submit an application to the Radiation Safety Committee for evaluation. These forms can be found on the MSC website for Institutional Compliance Committees (<http://committees.rcm.upr.edu/radiation.html>). The RSO does an initial perusal of the application and submits it to the RSC for evaluation.

The RSC must approve the appointment of all Authorized Users. Approval carries many responsibilities. Each Authorized User must be familiar with 10 CFR 19, 10 CFR 20, safe

radiological procedures, and all related requirements of UPR MSC. Authorized Users should designate an Alternate Authorized User and list their experience and training on the Authorized User Form, which should be submitted to the RSO and the RSC. The Alternate serves in the absence of the Authorized User and can assume any duties as assigned. Any delegation of work does not shift responsibility from the Authorized User. He or she must provide adequate supervision to ensure the safety of all personnel using radioisotopes and of any persons who work in the vicinity of the radioactive materials. Authorized Users are expected to fully support the ALARA program.

The Authorized User must:

1. Call the emergency medical service or fire department (**Ext. 1000**) immediately in the case of any fire, explosion, or major accident and tell the dispatcher that the accident involves radioactive materials. Then: notify the Office of Radiation Safety immediately.
2. Notify the RSO immediately of any spill of radioactive materials and of any known or suspected overexposure of personnel.
3. Follow the procedures for a spill as outlined in Part 2, Section III of this manual.
4. Ensure that all laboratory personnel, including guest investigators, complete the UPR MSC Radiation Safety Training before they start working in the laboratory as Radiation Workers.
5. Ensure that the laboratory has a security plan in case of an accident involving radioactive material. This security plan is submitted with the Authorized User Form. The security plan should follow the security recommendations outlined in this Manual. Immediately notify the RSO of any necessary changes in the laboratory's security plan. Strict adherence to the Security Plan is required.
6. Properly label all radioactive materials in the laboratory.
7. Signs and posted notices required by NRC should be displayed in the laboratory in a visible location.
8. Ensure that all laboratory personnel comply with UPR MSC radiation safety regulations, policies, and procedures governing the use of radioactive materials as outlined in this Manual and required by the Nuclear Regulatory Commission.
9. Notify the RSO immediately of any termination of employment of Radiation Workers that are listed on the Authorized User Form by submitting an amendment to the license. All personnel monitoring equipment, such as film badges and rings, should be returned to the RSO at this time.
10. Verify that radiation workers in your laboratory make proper use of personnel monitoring equipment such as thermoluminescent dosimeters (TLD's) when appropriate, and confirm that this equipment is always worn in the laboratory where any procedures involving radioactive materials are performed.
11. Ensure that all orders for radioactive materials are initiated only by the Authorized User or his/her representative.

12. Ensure that all orders are received only by the Authorized User or his/her Alternate or designated Radiation Worker and that the radioactive materials are immediately stored in a storage area designated for radioactive material in a secured laboratory.
13. Keep complete and accurate records of all radioisotopes received, used, and disposed of. This information should be available at all times, particularly during inspection.
14. Each Authorized User should have an up-to-date record of the quantity of radioisotopes on hand at any given time.
15. Each authorized user should maintain an up-to-date binder with all the necessary documentation required by NRC. This binder should contain:
 - (a) copies of all purchase orders of radioactive material
 - (b) results from wipe test when receiving radioactive material
 - (c) inventory of all stored radioactive material
 - (d) name of compound and isotope, date, and amount used each time radioactive material is used
 - (e) results from wipe tests after each experiment involving radioactive material
 - (f) log of radioactive disposal
 - (g) a current list of all Radiation Workers and Permitted Workers who use radioactive materials and copies of their training certificates.
 - (h) if radiation worker use film badges or rings, a copy of their exposure record will be available at the Radiation Safety Office.
 - (i) copy of the broad scope license of UPR MSC.
16. Assume responsibility for the proper disposal of all radioactive waste.
17. Maintain exposures ALARA (As Low As Reasonably Achievable) through laboratory procedures, shielding, and the use of gloves and other protective clothing. Practice the principles of external protection, i.e. minimize time, increase distance and use shielding when working with radioactive material
18. Assist the RSO, the Radiation Safety Committee of the UPR system or NRC in any surveys that are conducted as part of the UPR MSC Radiation Safety Program.
19. Ensure that laboratory is surveyed by laboratory personnel after each experiment and by personnel of the Radiation Safety office at least once per month.
20. **Specific instructions for surveys are in *Part 1, Section P* of this Radiation Safety Manual.**
21. Ensure that all problems in the laboratory related to radiation safety are identified and corrected in a timely manner or as soon as identified as the result of an authorized survey.
22. Ensure that before any equipment leaves the laboratory it is surveyed for radioactive contamination and decontaminated if necessary.
23. Notify the RSO if work with radioisotopes is terminated. The Authorized User can permanently discontinue work with radioactive materials, or can be put on inactive

status, which would imply that work may continue in the future. Inactive Users can be returned to Active status by submitting a written request to the RSC.

23. If the Authorized user request to be put on an inactive status, all radioactive material, personnel monitoring badges and any other issued materials or equipment must be returned to the Radiation Safety Office. Also, all radiation-related signs must be removed from the laboratory.
24. Every year all Authorized Users must renew their authorization to continue using radioisotopes. This renewal shall include a review of all application protocols, procedures, and personnel assignments. If a User does not plan to use radioisotopes, he (she) any request termination.
25. The authorized User is responsible for the clearance of all radioactive materials, personnel and laboratory equipment and benches as well of completing all related documentation prior to vacating or renovating the laboratory facilities.

Authorized User (AU) Absences:

A permit is granted on the grounds that the permit holder is aware and responsible for the activities in the radioisotope facilities. If a permit holder is taking a sabbatical or other type of leave where he or she will not be able to administer this responsibility, arrangements must be made prior to taking the leave. Authorized Users (AU) may be occasionally absent from the laboratory for various reasons. During such absences, another individual must be named to assume the responsibility for the correct usage and management of radioactive materials. When the absence is less than 60 days, a responsible graduate student or technician may be appointed to assume responsibility. If the absence is greater than 60 days, an alternate AU with the appropriate radioisotope approvals must be designated, and must agree to assume responsibility.

Before departure, the RSO must be notified in writing of the absence, duration and the name of the alternate AU who will oversee the use of radioactive material. The stand-in AU must have all the authorizations necessary to oversee the uses of the radioactive materials possessed by the absent AU. The RSO must be notified in advance of the intended absence. During the absence, shipments will still be logged under the absent AU's inventory, but all oversight will be conducted by the stand-in AU. Any permit holder acting on behalf of another permit holder is responsible for all activities under both permits and will be subject to any necessary disciplinary action. If a permit holder does not advise the RSO prior to taking leave, the facilities may be considered to be abandoned.

Failure to comply with the rules and regulations set forth above and throughout this manual may lead to disciplinary actions and/or the cessation of radioisotope shipments and experiments. The RSO may terminate any radioisotope use and/or research if deemed necessary. Suspension or termination of approval to use radioactive materials may result from situations jeopardizing the health, safety and or environment of the MSC community.

F. RADIATION WORKERS

The responsibilities of the Radiation Worker:

The manual is a practical reference, but users must also have technical knowledge of radiation and some experience in handling radioactive materials. 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 ultimate responsibility lies with them for safety and compliance with laws and regulations. For this reason, it is critical that they be aware of the risks, safe practices and requirements for use, management and disposal of radioactive materials.

The term "worker" is used by the university to identify an individual who uses radioactive material in the course of his/her employment or study with the university. The Workers may be graduate students, undergraduate students, technicians, post-doctorates, visitors, or any other individual working under the supervision of an Authorized User, who handles radioactive material. The following items are to be adhered to at all times by radiation workers:

1. Each worker must complete the appropriate Radiation Safety Training Course for their work area and isotope use.
2. Workers are responsible for adhering to all laws, rules, regulations, license conditions and guidelines pertaining to the use of radioactive materials as outlined in this Manual and required by the Nuclear Regulatory Commission.
3. Read the MSC Radiation Safety Manual and be responsible for its contents as applicable to their duties in the laboratory.
4. Workers must wear their assigned radiation dosimeter when using radioactive materials, if applicable. Maintain exposures ALARA through safe laboratory procedures, including shielding, gloves and other protective clothing.
5. Workers must practice ALARA (As Low As Reasonably Achievable) in their work, and minimize the potential for exposures, contamination or release of radioactive materials.
6. Radiation work areas must be monitored by the user after each use of radioactive material, where applicable. If contamination is found, it must be cleaned up.
7. It is the responsibility of the worker to clean any contamination or spills that occur in their work area. DO NOT LEAVE IT FOR ANOTHER PERSON TO CLEAN UP. Notify RSO/Radiation Safety Office immediately of any spill of radioactive materials and any known or suspected radiation exposure. The AU and RSO will supervise/assist. Follow the procedures for a spill as outlined in **Part 2, Section III.**
8. No changes in experimental procedures using radioactive materials are to occur without the approval of the AU. Do not take short cuts. Changes in experimental procedures impacting upon safety (higher quantities, higher risk, use in animals, etc.) must be approved by the RSC.
9. Any abnormal occurrence must be reported immediately to the AU, such as spills, significant contamination, equipment failure, loss of radiation dosimeters and unplanned release. If the AU cannot be reached, contact the RSO.
10. Workers are responsible for reporting any loss or contamination of the dosimeter to the RSO.

11. Workers are responsible for informing the RSO of any exposures which have occurred at a previous employer when beginning employment at MSC. They are also responsible for notifying the RSO of termination of employment and returning the radiation dosimeter at the end of their employment.
12. Workers are responsible for maintaining security of radioactive materials. Follow the recommendations of the Authorized User for those procedures that are specific to their laboratory for the storage, usage, recording, and disposal of radioactive materials.
13. Call the Security Office of the MSC immediately for any fire, explosion, or major accident and tell the dispatcher that the accident involves radioactive materials. Next, notify Radiation Safety Office and their immediate supervisor and/or the Authorized User responsible for their laboratory. Emergency numbers must be posted near the telephone and visible to the laboratory personnel.

G. PERMITTED WORKERS

A permitted worker is a laboratory worker who does not work with radioactive materials but works in a radiation laboratory. To be a permitted worker, the employee must successfully complete the "Radiation Safety Training Course" or equivalent.

The duties of Permitted Workers are as follows:

1. Enroll, attend and complete the five hour Radiation Safety Training Course.
2. Wear issued radiation monitoring badges at all times in the radiation laboratory.
3. Use the principles of time, distance, and shielding to protect themselves from radiation exposure.
4. Confer with radiation workers to find out where radioisotopes are used and stored so that these areas can be avoided.
5. Report any observed radiation safety infractions, shortcomings, or failures to the RSO in a timely manner.

H. TRAINING

Radiation Safety Training:

All Authorized Users (AU), and Radiation Workers under their supervision who work with radioisotopes, must receive instruction on radiation safety, biological effects of radiation, regulatory requirements, and laboratory techniques. The MSC Radiation Safety Program is designed to achieve strict compliance with applicable Federal regulations. *Title 10, Code of Federal Regulations, Part 19, Section 12 "Instructions to Workers" (10 CFR 19.12)* is the regulation requiring training of all individuals working in or frequenting any portion of a restricted

area associated with radioactive materials or radiation. To meet the regulatory requirements on the training of radiation workers, the Radiation Safety Office operates an extensive training program. The type of radiation safety training required depends on the nature of their involvement with sources of radiation.

The goal of providing radiation safety training to the employees of the University of Puerto Rico, Medical Science Campus is to empower workers to take personal responsibility for minimizing their exposure to radiation. By providing each employee with knowledge of radiation and its biological effects and the regulations governing its use, the University of Puerto Rico, Medical Science Campus can help provide an environment that is safe for its patients, students, visitors and workers. The content of radiation safety training courses will be determined by the Radiation Safety Officer and the appropriate Radiation Safety Committee based on applicable regulatory guidance, industry consensus standards, and the specific needs of the target audience.

Also, people that will receive radiation safety training from the Radiation Safety Office personnel must be associated with the University of Puerto Rico, Medical Science Campus. They are required by the Radiation Safety Committee, to present evidence regarding this matter.

The AU (principal investigator) is responsible for ensuring that all radioactive material users within his/her laboratory are trained on the safe use of radioactive material prior to beginning work with the radioactive material. This training must include information on the safe use, handling, storage and disposal of radioactive material as well an explanation of the risks associated with exposure to ionizing radiation. The Authorized User is responsible for maintaining documentation of the completion of required training and will be required to supply such documentation to the Radiation Safety Officer or his/her designee as a condition for continued authorization to use radioactive material or radiation sources.

In addition, all ancillary personnel that enters into the area where radioactive material is used or stored is also required to receive radiation safety training. Training is also offered to those with incidental contact with nuclear substances and radiation devices, for example housekeeping, skilled trades, campus security police, receptionists, movers and recyclers. From time to time, as regulations change and new requirements are introduced, it will be necessary to conduct specialized and/or refresher training.

Each principal investigator is responsible for instructing all new users working with radioactive material of the health problems associated with use of the radioactive material, the precautions or procedures for minimizing radiation exposure, and the purpose and function of protective devices employed. New users are required to take the radiation safety course offered by the Radiation Safety Office. The annual refresher course is also offered by the Radiation Safety Office. This annual refresher course can be accomplished by viewing the radiation safety video available at the following MSC web page: <http://www.rcm.upr.edu/vidsrcm/radiationsafety.htm> Users may take an on line Radiation Safety Course every other year as long as they provide evidence of the training.

This training must be documented on the **“New User Amendment and Training Certification”** form and be on file with the Radiation Safety Office. This form will assist the Authorized User (AU) in documenting the training that an individual receives under his/her supervision. If the AU is unable to provide the training, a senior laboratory technician may provide the necessary training. A letter from the AU must be sent to the Radiation Safety Office authorizing the individual to provide training in their place to the laboratory personnel. However, this training

does not relieve the Authorized User from the responsibility of the individuals working in his/her laboratory.

Please make sufficient copies of the **“Radiation Safety Training Program” form** and give one to each employee and student who is currently working or will work with radioactive materials. Please have each employee fill out this form and return it upon request from the Radiation Safety Office.

Each employee is required to have annual refresher training.

Minimum training requirements:

a. Authorized Users for radioactive materials:

1. Purpose of the ALARA program
2. Radiation Safety Management
3. Radiation dose limits
4. Personnel Monitoring
5. Notices and Caution Signs
6. Use of radioactive materials
7. Security of Areas Using radioactive materials
8. Procurement, receiving radioactive materials, inventory control, storage and transfer of radioactive material
9. Survey performed
10. Radioactive waste
11. Manual of radioisotope basics
12. operational use of a survey meter, LSC and gamma counter
13. Proper use and location of film badge/ring badges

b. Individuals working under an Authorized User:

1. Purpose of the ALARA program
2. Radiation dose limits
3. Personnel Monitoring
4. Notices and Caution Signs
5. Use of radioactive materials
6. Security of Areas Using radioactive materials
7. Procurement, receiving radioactive materials, inventory control, storage and transfer of radioactive material
8. Survey performed
9. Radioactive waste
10. Manual of radioisotope basics
11. Operational use of a survey meter, LSC and gamma counter

12. Proper use and location of film badge/ring badges

Individuals or Groups Requiring Training and Frequency Done:

Individuals employed by the University of Puerto Rico, Medical Science Campus fall into four general categories with respect to their exposure to radiation. Training occurs on an as-needed basis. However, the Radiation Safety Office subscribes to some basic guidelines for the frequency and intensity with which different groups receive their training. These include:

- a.** Before assuming duties with, or in the vicinity of, radioactive materials (for users and awareness-level employees).
- b.** Whenever there is a significant change in duties, regulations, or the terms of the license (for users and awareness-level employees).
- c.** Radiation workers: initial training including instruction in the proper use, handling and disposal of radioactive material and other sources of ionizing radiation. The content of the initial training may be modified for the specific job responsibilities.
- d.** Radiation workers and certain ancillary workers: periodic refresher training.
- e.** Re-training of workers whose job responsibilities change concerning their use of or exposure to ionizing radiation, or who request additional radiation safety training.
- f.** Special training in connection with incidents involving a spill, accident, changes in regulations, or a documented overexposure.

Radiation Workers: those workers whose major responsibilities involve working with sources of ionizing radiation or radioactive material. They would include principal investigators, technicians and Radiation Safety Office personnel.

1. Authorized User (Principal Investigator and Nuclear Medicine Physicians):

- They must present evidence of prior training and experience of working with radioactive material.
- They are also required to take a ten (10) hour training course from the Radiation Safety Office of the University of Puerto Rico, Medical Science Campus. This training must be completed before the approval of the Radioactive Material Use Permit.
- After this a one hour refresher course will be required annually. The PI will receive radioactive information concerning any changes to the ALARA Program of the University of Puerto Rico, Medical Science Campus annually.

2. Radiation Worker (Lab. Technicians and Nuclear Medicine Technologist):

- The AU must 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.
- They are also required to take a five (5) hour training course from the Radiation Safety Office of the University of Puerto Rico, Medical Science Campus. This training must be completed before starting working with an authorize user.
- After this a one hour annual refresher course will be required.

Permitted Worker: A permitted worker is a person who works in a laboratory where radioactive material is used, but that person does not handle any radioactive materials. To be a permitted worker, the employee must successfully complete a "General Radiation Safety Training Course" or equivalent. This can be accomplished by viewing the "Radiation Safety" video. The AU must certify in writing that they received this training and present a copy of this certificate to the Radiation Safety Office. **This video is available at the MSC web page: <http://www.rcm.upr.edu/vidsrcm/radiationsafety.htm>**

Ancillary Workers: All ancillary non-laboratory persons who frequent restricted areas, such as janitors, environmental specialists, housekeeping, secretarial staff, security guards, engineering service personnel, and shipping and receiving workers, must receive instruction provided by the RSO in accordance with 10 CFR 19 & 20. These courses are conducted as needed by the RSO, tailored to the needs of these occupational groups, and are designed to inform these non-laboratory personnel about radiation hazards and appropriate precautions. They can be informed by the AU or designee (Lab Technician or Nuclear Medicine Technologist) about radiation hazards and the appropriate precautions.

- They are also required to take a five (5) hour training course from the Radiation Safety Office of the University of Puerto Rico, Medical Science Campus. This training must be completed before starting to work in the vicinity of radioactive materials.
- After this a one hour annual refresher course will be required.

Summer Student Training: Summer students and other temporary employees at the Medical Science Campus must also comply with the requirement for training before beginning work with radioactive materials. For these individuals, the Radiation Safety Office offers similar training, but there is no final examination or certificate for this training and students who take this course may not work with radioactive materials without direct supervision by someone who has completed the regular Ionizing Radiation Protection Course. They can be informed by the AU or designee (Lab Technician or Nuclear Medicine Technologist) about radiation hazards and the appropriate precautions.

- The PI must 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.
- They are also required to take a five (5) hour training course from the Radiation Safety Office of the University of Puerto Rico, Medical Science Campus. This training must be completed before starting working with an authorized user.
- After this a one hour annual refresher course will be required.

Non-Radiation Workers: personnel who would not normally be expected to encounter radioactive material or radiation sources in the course of their employment at the University of Puerto Rico, Medical Science Campus. These include administrators and administrative assistants, food service employees, clerical staff, and so forth.

Annually the RSO provides a refresher training course for all laboratory personnel working with radioactive materials, to update them on training and to present information about new regulations or procedures. Because violations may have occurred during the past year as noted by the RSO during laboratory surveys, the RSO will also re-emphasize certain rules and regulations.

These groups will require different levels and frequencies of training. Authorized Users are required to submit evidence of prior training during the application process for medical or research use of radioactive material and radiation sources. This prior education and training may be applied in lieu of certain initial and update training requirements.

If laboratory personnel have been in an inactive status for more than two years, he/she will be required to retake the "Radiation Protection Training". The former Authorized User must reapply for authorization and must update all required training and experience information on the Authorized User application, and then must be re-authorized by approval of the Radiation Safety Committee.

Laboratory personnel may contact the Radiation Safety Office for additional course information. The RSO regularly notifies all Authorized Users of upcoming courses.

I. PROCUREMENT

1. Application for the use of Radioactive Materials:

Approval for the use of radioactive materials is given by the RSC and is reviewed periodically. Approval may be obtained by submitting an application describing the requested material and quantity to be used, the location, individuals who will handle the material, present evidence of training and experience of the applicant working with radioactive material, the training of workers, the protective equipment to be used, if any, monitoring equipment, a brief description of experimental procedures and protocols with emphasis on potential safety concerns, methods and a description of measures employed to minimize radiation exposure to the experimenter, any human subjects and the protection of the environment and waste disposal information.

New applications are required for the use of a new radionuclide, for a change in experimental procedures which have an impact on safety, and for a change in chemical or physical form of a material previously approved. **(View Appendix ____, Application for the Use of Radioactive Material for Biomedical Research)**

2. Amendments for a Radioactive Permit:

Amendments to current approvals are given for slight increases in quantity or moderate changes in chemical form, and may be obtained by submitting an application stating the desired change and the reason for the change, referencing to the original approved application to be amended. Applications for approval or amendments should be directed to the RSO. Laboratories that have been granted approval for use of radioactive material may need to amend their authorization. Amendments are considered changes in laboratory locations, radioisotopes, radioisotopes limits, and proposed uses, laboratory personnel who

work with radioactive material, changes in use and storage areas and other minor changes. An Authorized User must submit a new application if other radionuclides are to be used or if the change in procedures will significantly alter radiological hazards. Forms are available on the Radiation Safety Committee website. <http://www.committees.rcm.upr.edu/radiation.html>.

The Radiation Safety Officer (or his/her designee) will review the application, evaluating the facilities available, the training and experience of the applicant and staff for the proposed use, and the details of the work to be performed. After the review, including any necessary modifications, the application will be forwarded to the Radiation Safety Committee with a recommendation for approval or disapproval. The application must be approved by a two-thirds majority vote.

The procedures approved in the application become the conditions under which the researcher and his/her personnel are authorized to use radioactive material. Any subsequent change in procedure regarding the use, storage or disposal of sources must be reviewed and approved by the Radiation Safety Committee.

Any AU that might use radioactive material in studies involving animals must submit the investigation proposal to the Institutional Animal Care Use Committee (IACUC) for their proper evaluation and authorization.

1. Procedures to be conducted to amend an authorization:

a. Notifications for room changes (adding new lab or discontinuing use in a lab)

Radioactive material may only be used in laboratories and cold rooms approved by the University Radiation Safety Committee. In order to amend your areas of use, submit an amendment request form listing the change (building and room number) and the effective date of this change to the Radiation Safety Office. If the room change involves the termination of radioactive material work in that lab, the Radiation Safety Office will perform a closeout survey certifying that no radiological hazards exist in the space.

Please note: If your lab is moving to a new location or if you are leaving the University, the Radiation Safety Office requires advance notification (1 week) to schedule the surveys, radioactive waste removal, and cancellation of all radiation safety related services. Submit this by email to the RSO. Lab equipment used in radioactive material experiments must be surveyed prior to packaging by the moving company. In addition, a close-out survey is conducted after the movers have removed all equipment.

b. Notification for changes in possession limits and changes in physical or chemical form.

In order to amend the authorization, submit an amendment request form listing the change to the Radiation Safety Office. In order to add a new radiochemical, complete and submit an "Application for Non-Human Use of Radioactive Material" to the Radiation Safety Office.

c. Adding laboratory personnel who will work with radioactive material

Laboratory personnel who work with radioactive material are required to be listed on the application. In order to update the laboratory personnel list, a "Training Certification" form must be submitted to the Office of Radiation Safety. In addition, labs are required to update their Radiation Safety Training Certificate form and list of lab personnel.

d. *Adding or modifying survey instruments*

In order to add a new survey instrument, add a new probe, or discontinue use of a survey instrument, you are to submit a memo or email outlining the change including the instrument's model and serial number. A member of the Radiation Safety staff will contact the lab designee to conduct the change.

Please note: If you have purchased a new instrument, the Radiation Safety Office will affix a sealed source to the instrument to be used for its operational checks. A copy of the calibration certificate must also be submitted to the Radiation Safety Office. If you are unable to locate the calibration certification, the Radiation Safety Office will be required to recalibrate the instrument.

3. Cancellation of a Radioisotope Permit:

Cancellation of a permit may occur at any time. Cancellation of a permit is required if a permit holder is leaving the University of Puerto Rico, Medical Science Campus and must be completed prior to departure. The permit holder must notify the RSO to cancel the permit. Any special disposition required of radioactive material held under the permit should be noted in the request (e.g. *transferring radioactive material, storage pending return, etc.*). The RSO will make all necessary arrangements including the decommissioning of any facilities no longer required for radioisotope work.

A permit may also be cancelled at the time of permit renewal. If the permit holder is not currently using radioisotopes and has no immediate plans to resume such work, it is recommended that the permit be cancelled. If the work with radioisotopes resumes, the permit may be reactivated.

In the case of abandoned facilities, the RSO will immediately arrange for the decommissioning of the facilities and the disposal of all radioactive material in those facilities. A facility may be declared to be abandoned when the permit holder is no longer in the employ of the University of Puerto Rico, Medical Science Campus and has not notified the RSO. A facility may also be declared to be abandoned if the permit holder takes a sabbatical/ leave, is not at the University of Puerto Rico, Medical Science Campus facility on a regular basis and has not notified the RSO of any alternative arrangements. If significant costs are involved in this procedure, all costs will be charged to the department with the abandoned facility.

4. Ordering Radioisotopes and Other Radioactive Materials:

The purchase of radioactive material including both licensed and license-exempt quantities is handled through the Radiation Safety Office. Principal investigators are encouraged to establish standing and/or blanket orders for the purchase of radioactive material with the Radiation Safety

Office. To establish these orders, each principal investigator must complete the appropriate purchase request and hand carry it to the Radiation Safety Office for approval. Instructions on how to complete the purchase request may be obtained from the Radiation Safety Office. All orders for radioactive materials to be purchased through the MSC shall not be processed until approved by the Radiation Safety Office.

Once your standing and/or blanket order has been established, research groups should place their radioactive material orders with the Radiation Safety Office. Only principal investigators with an approved and unsuspended application will be allowed to establish standing and/or blanket orders and place radioactive material orders. All requests should include the following: Principal Investigator's Name, Nuclide, Maximum Activity, Vendor, and Chemical Form. Additional information is requested to present: total amount of nuclides in possession Activity in uCi or mCi) and total amount of each type of radioactive waste stored in the laboratory (vials, solids or liquids). If orders do not have all of the information listed, it will cause a delay upon approval of the radioactive material.

Note that orders for radioactive material must be limited to the isotopes, chemical forms, and maximum activity per shipment as shown on the application form. Orders for other materials or activities greater than specified on the application cannot be ordered. Researchers are required to submit an amendment application to the Radiation Safety Office for the approval of the RSC.

The Radiation Safety Office will review the order request to determine the following:

1. That the user has been authorized to use the type and quantity of radioactive material being ordered. The name of the Authorized User must be clearly indicated on the order.
2. That the radioactive material being ordered will not cause the Authorized User's inventory limits to be exceeded.
3. That the Authorized User has no unresolved items of safety noncompliance, including responses to survey reports and training notices.
4. That the Authorized User's radionuclide inventory reports are current.

When the above criteria are met, the order will be approved and signed by authorized personnel of the Radiation Safety Office. The Principal Investigator or designee will hand to the Radiation Safety Office a package receipt when radioactive material is received in the laboratory. The amount received must be included as an inventory record. If the above criteria are not met, the Authorized User will be notified by telephone to expedite acquisition of the necessary information. Authorization is based on prior protocol approval by the RSC as described earlier. Every shipment of radioactive material received must be tracked in the inventory database and added with the campus totals. This is to prevent an individual Authorized User, or the campus, from exceeding individual approval or MSC license possession limits respectively.

Note: The purchase of radioactive material by credit cards is not approved by the Central Administration of the University of Puerto Rico and the Medical Sciences Campus will comply with this criteria.

5. Receiving and Monitoring Radioisotope Shipments:

The Radiation Safety Office must approve all orders for radioactive material and ensure that the requested material, quantities, manufacturer, and model are authorized by the license and that the possession limits are not exceeded.

Receipt of radioactive materials shipments should be between 7:00 AM to 4:00 PM Monday to Friday. Shipments are delivered directly to the Authorized User's laboratory. A designated, trained individual will receive it and follow the guidelines for package receipt and opening.

Upon receipt of a shipment, the exterior of the package is checked for contamination (as required by regulations). The package must be surveyed at its surface and at one meter with the GM counter and a wipe test must be performed. The results must be documented in units of mRem/ hr and dpm and kept in the log book. **(View Appendix____, Receipt of Radioactive Material and Disposal of Packing Material Form)**

The RSO and the final delivery carrier must be notified immediately by telephone and telegram, mail or fax if contamination on any package exceeds 0.001 uCi (2200 dpm) per 100 square centimeter (for beta and gamma emitting radionuclide) or if the external radiation levels exceed 200 mrem/hr at any point on the external surface (10 CFR 20.1906(d)). The RSO will notify the NRC of this situation by phone or by fax.

The Radiation Safety Office personnel will notify the PI that the radioactive material ordered has arrived and will make the arrangements with the PI for the pick up of this package. A form will be signed by the person who receives the package.

A refrigerator will be available in the Radiation Safety Office for those radioactive materials that need to be stored in specific temperatures upon receipt. It is the PI's responsibility to pick up the package the same day or within the next 24 hours after delivery.

If the package is not contaminated, the RSO or his designee will stamp the package approved and will sign and date it. After being recorded in the radioactive material logbook, packages will be delivered to the Authorized User/laboratory.

If an Authorized User or Radiation Worker opens a package and discovers that the contents have been spilled because the container has been broken or is cracked, he or she must notify the Radiation Safety Office immediately for guidance. The package should be contained to a restricted area to minimize spread of contamination until it can be safely sealed and removed.

For deliveries during off-duty hours, the RSO will tell security personnel or other designated persons to accept delivery of radioactive packages in accordance with procedures outlined in the sample memorandum. **(View Appendix____, Memorandum Form).**

6. Procedures for Safety Opening Packages Containing Radioactive Material:

For packages received under the specific license, the following procedure for opening each package will be followed **(View Appendix____, Receipt and Survey of Radioactive Material and Disposal of Packing Material):**

1. Put on gloves to prevent hand contamination.
2. Visually inspect the package for any sign of damage (e.g., wet or crushed). If damage is noted, stop the procedure and notify the Radiation Safety Officer (RSO).
3. Measure the exposure rate from the package at 1 meter and at the package surface. If it is higher than expected, stop and notify the RSO. (The "transport index" noted on packages with "Yellow II" or "Yellow III" labels is the approximate dose rate, in millirems per hour, at 1 meter

from the package surface (10 CFR 71.4); the surface dose rate for Yellow III packages should not exceed 200 millirems per hour. The dose rate from packages with "White I" labels should be less than 0.5 millirems per hour at the package surface (49 CFR 172.403).

4. Open the package with the following precautionary steps:
 - a) remove the packing slip.
 - b) open the outer package following the supplier's instructions, if provided.
 - c) open the inner package and verify that the contents agree with the packing slip.
 - d) check the integrity of the final source container. Look for broken seals or vials, loss of liquid, condensation, or discoloration of packing material.
 - e) if anything is other than expected, stop and notify the RSO.
5. For all packages wipe the external surface of the final source container and remove the wipe sample to a low-background area. Assay the wipe sample to determine if there is any removable radioactivity. The NaI well counter will be used to assay wipes. The detection efficiency must be determined to convert wipe sample counts per minute to disintegrations per minute. Note that a dose calibrator is not sufficiently sensitive for this measurement. Take precautions against the potential spread of contamination.
6. Check the user request to ensure that the material received is the material that was ordered.
7. Monitor the packing material and the empty packages for contamination with a radiation detection survey meter before discarding:
 - a) if contaminated, treat this material as radioactive waste.
 - b) if not contaminated, remove or obliterate the radiation labels before discarding in in-house trash.
8. Make a record of the receipt.

7. Transfer of Radioactive Materials:

Transfer of radioactive material between investigators of different projects must be approved by the Radiation Safety Officer (RSO) or Radiation Safety Committee (RSC). These transfers must be between "committee approved" Authorized Users, and within the limits of the approved quantities. The transfer should not take place until authorized by the RSO or the RSC. All transfers must be done in a way that minimizes the probability of spillage or breakage. Double containers must be used, including suitable shielding, for such transfers.

Licensed material shall not be transferred or shipped from one institution to another without the approval of the RSO. Transfer of radioactive material between Authorized Users, or between a User and an outside facility, are permitted as long as such transfers are in compliance with Medical Science Campus license conditions and any other applicable regulatory requirements. Transfer of radioactive material to another institution requires an NRC license to possess that material by the receiving institution, and oversight by the Radiation Safety Officer of the receiving institution. The Radiation Safety Office must be notified before any transfers take place, either between MSC Authorized Users or with outside facilities.

Users must record any transfers on the **Radionuclide Inventory Form. (View Appendix _____ Isotope Inventory in Refrigerator or Freezer)** Any material that is either donated or received free-of-charge (e.g., received on a trial basis or free samples, or samples from other research facilities) must be approved prior to receipt by the RSO or the RSC.

8. Transportation or Shipment of Radioactive Material:

The transportation or shipment of radioactive material on campus and to other institutions, must comply with both State and United States Department of Transportation (USDOT) regulations. Unless specifically exempted by the Radiation Safety Officer, all radioactive shipments and transport within or from the UPR MSC must receive prior approval from the RSC. In addition:

1. Transport of radioactive material off-campus by University of Puerto Rico employees, as checked baggage on public conveyances, is prohibited.
2. Radiation sources (such as x-ray machines, x-ray diffraction systems, analytical units, accelerators, etc.) or equipment containing sealed sources of radioactive material (such as liquid scintillation/gamma counters, gas chromatograph electron capture detectors, moisture content gauges, etc.) shall not be transferred, donated, sold or discarded without notification of and approval by the Radiation Safety Officer.

10. Radioactive Material License Status:

An Authorized User may request that his/her authorization to use and store radioactive materials be temporarily changed to an Inactive Status. This status allows the Authorized User to perform and document survey/wipe tests and inventories on a less frequent basis (quarterly). This provision is designed for laboratories which are not planning on using radioactive materials for at least six months. The Authorized User may not use radioactive materials with this status (this is a storage only authorization). The Authorized User must submit a request to the Radiation Safety Officer to return to active status when so desired.

The "status" of each Authorization (and Authorized User) falls into one of following categories:

- a. Active:** The user is authorized by the Radiation Safety Committee to use, purchase and possess radioactive material including equipment containing sealed sources, irradiators, or radiation producing machines. This person purchases or performs experiments with radioactive material or radiation sources at least once in a year. A person must remain classified as "active" if they possess any amount of usable unencapsulated radioactive material or if they are using equipment containing sealed sources, irradiators, or radiation producing machines.
- b. Inactive:** The user is authorized to use, purchase and possess radioactive material including equipment containing sealed sources, irradiators, or radiation producing machines. An inactive user has chosen not to perform experiments utilizing unencapsulated radioisotope or use radiation equipment for an extended period of time exceeding one year. A user who wishes to change to inactive status must notify the Radiation Safety Officer (RSO) and the Radiation Safety Committee (RSC) in writing of this decision. An inactive user shall have no usable unencapsulated radioactive material (including radioactive waste) in their possession. Inactive users who have equipment containing sealed sources, irradiators, or radiation producing machines must not use

them and must declare this information to the RSO and the RSC, in writing, at the same time as they request "inactive" status. If an inactive user desires to reinstate their "active" status, they must notify the RSO and the RSC in writing and fulfill "Active" status training requirements.

- c. ***Terminating Employment:*** If an Authorized User terminates employment at the Medical Science Campus of the University of Puerto Rico, the RSO and the RSC shall be notified at least one month beforehand. Arrangements must be made to remove or reassign any radioactive materials. Before the termination date, the Radiation Safety Office will conduct a final radiation survey of the radioisotope laboratory in order to determine the presence of unused radioisotopes and/or the presence of contamination. This person has no radioactive material, equipment containing radioactive material, or radiation producing equipment. A "terminated status" Authorized User shall have completed (either prior to termination or in absentia) a "close-out" procedure, in which the inventory of radioactive material under the Authorization has been disposed or transferred, radioactive waste has been removed, and rooms and facilities have been surveyed and determined to be free of radioactive contamination. Documentation of the "close-out" will be maintained by the Radiation Safety Office.

Radiation workers who terminate their education and/or employment at the university shall notify the Radiation Safety Office and the RSC, and their badges must be returned. Federal law, implemented on January 1, 1994, mandates that new workers who will use radioactive materials must supply the current year's exposure report to the RSO prior to beginning work with radioactive materials. To meet this requirement at future locations, this information will be supplied to a worker leaving the Medical Science Campus of the University of Puerto Rico after the radiation detection badge has been returned to the Radiation Safety Office.

- d. ***Termination of Laboratory Operations (Close – Out):*** When an Authorized User ends his/her affiliation with University of Puerto Rico, Medical Science Campus or desires to terminate his/her radiation license, any laboratory space controlled by that user must be decommissioned (cleaned out by the Authorized User and checked by the Radiation Safety Office) before the area can be returned to non-radiation use or occupied by another Authorized User. Any Authorized User who anticipates terminating his or her Authorization shall notify the RSO and the RSC of the termination in writing or via electronic mail no less than thirty (30) days prior to the anticipated date of termination.

- e. ***Decommissioning***

Permittee Responsibilities:

1. Notify Radiation Safety Office when the Radioactive Materials Permit is no longer needed.
2. Transfer remaining stock materials to radioactive storage area approved by the RSO.
3. Dispose of all unwanted radioactive waste through the Radiation Safety Office.
4. Clean all areas where radioactive materials or waste were used and stored.
5. Perform swipe tests of radioactive use areas.

6. Notify Radiation Safety Office and schedule a decommissioning survey be performed by Environmental Health and Safety office.
7. Transfer the following records to Radiation Safety Office:
 - All actions followed to reduce the contamination of a worker, including name of person surveyed, description of incident with prior work activity, probable cause and steps taken to reduce future incidence of contamination, times, dates, and the surveyor's name and signature
 - Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment or site
 - Records should include any known information or identification of involved nuclides, quantities, forms and concentrations
 - Limit records to instances when contamination remains after cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in porous materials such as concrete
8. Remove all radiation symbols and sign upon decommissioning release of area by RSO.
9. Ensure that decommissioning procedure is followed by the Permittee (Faculty or permitted employee under Department's supervision).

I. INVENTORY AND RECORDS

The NRC requires that all licensees maintain records tracking the receipt, use and disposal of radioactive materials. This is done with an inventory maintained by the Radiation Safety Office. Use logs are required in laboratories utilizing unsealed isotopes. The log should contain records of amounts used, who used them and dates of use for each shipment received. Physical inventories are conducted at intervals not to exceed 6 months, to account for all sealed sources and devices received and possessed under the license.

The University is required to maintain accurate, timely records of the receipt, use, transfer and disposal of radioactive material in its possession. Authorized Users have this same responsibility for their sources. These records must be maintained by the Authorized User for at least three (3) years and be readily available for periodic review by Radiation Safety Office and/or regulatory personnel.

The Radiation Safety Office personnel will compare requisitions with database prior to the authorizing the purchase of radioactive material. Any package that was not approved by the Radiation Safety Office personnel will not be purchased. In the event that a free sample or material is received from another university, the laboratory will notify the Radiation Safety Office personnel within the next business working day. The material cannot be used until the Radiation Safety Office personnel has been notified and authorization has been given to use the material. The Radiation Safety Office personnel will then add the material to the data base and will provide an inventory sheet for the material. If it has been determined that a package was

received and the Radiation Safety Office personnel was not informed, the authorized individual will have their radioactive materials suspended. The RSC and the RSO will make this determination.

A number is assigned to each radioactive item/vial logged in through the Radiation Safety Office and is documented in the radioisotope receipt and disposal record.

A receipt of radioactive material and disposal of packing material form will be provided with each vial of radioactive material received by the Authorized User. Attached to this form should be a copy of all of the User's packing slips associated with all incoming radioactive material packages.

A disposition sheet to record each use of radioactive material in that specific vial should be available in and updated for each inspection (**Radioisotope Inventory Log Sheet Form**).

The **Isotope Inventory in Refrigerator or Freezer Form** should be completed for each radioactive material receipt.

Transfers to solid and liquid will be updated each month by the Authorized User and will be checked by the Radiation Safety Office personnel. The waste data must be accurate to ensure the University does not exceed the total possession limit for each radionuclide (**Radioactive Waste Pick Up Sheet Form**).

An Authorized User and/or a designee must keep records of all radioactive materials ordered, received, and disposed. The Radioisotope Inventory should be maintained in the laboratory. **Records must be maintained by the AU for a period of 3 years.**

Note: Packing slips must be strictly maintained to keep an accurate inventory. To accurately document the amount of radioactive material used at the workbench, a Radioactive Material Inventory should be maintained. Inventory of then radioactive materials should include the name of the physical/chemical form of the radioactive material, the amount (in millicuries) of radioactive waste, and the net quantity (in millicuries) of the radioisotopes on hand in the laboratory. The date of assay is required for accurately determining the exact activity on hand at any date. If the date of assay is not provided by the manufacturer, then use the date received in the laboratory as the date of assay and calculate the activity of the radioisotope using this assumption.

K. PERSONNEL MONITORING



Dosimeters -- According to 10 CFR 20.1502 “Conditions Requiring Individual Monitoring of External and Internal Occupational Dose”, personal monitoring devices (dosimeters) are required for workers who may receive 10 percent of the maximum dose of external radiation permissible under NRC’s regulations (**Table 2**). To apply for a monitoring device, laboratory personnel must complete a **Request for Radiation Monitoring Badge Form**, and return it to the Radiation Safety Office. The RSO will request the dosimetry records of new radiation workers from other institutions where they used radioactive materials. Old and new dosimetry records will be added to obtain cumulative records.

Exposure standards have been established by the NRC and set at a level where apparent injury due to ionizing radiation during a normal lifetime is unlikely. (There are unique standards for minors (< 18 years of age) and pregnant workers. However, personnel should not completely disregard exposures at or below these limits. It is the responsibility of each individual to keep his/her exposure to all radiation as low as is reasonable, and to avoid all exposures to radiation when such exposures are unnecessary.

The exposure limit for whole body exposures is lower than that for a single organ because all organs and tissues are exposed in a whole body exposure, while only a single organ is involved in the single organ exposure limits. The risk to the organ is incorporated in the exposure calculations, which must be done if organs or tissues are exposed. Occupational limits to external radiation for adult and minor radiation workers are given in the table below.

Table 2. Annual Maximum Permissible Dose Equivalent in mrem

Annual Maximum Permissible Dose Equivalent in mrem			
Part of Body	Adult Yearly (mrem)	Minors Yearly (< 18 yrs. age) (mrem)	Adult ALARA Yearly (mrem)
Whole Body, Head and Trunk, Active Blood Forming Organs (TEDE)	5,000	500	500
Lens of Eye (LDE)	15,000	1,500	1,500
Extremities (SDE) (Elbows, Forearms, Hands, Knees, Lower Legs, Feet)	50,000	5,000	5,000
Single Organ Dose (TODE)	50,000	5,000	5,000
Skin of Whole Body (SDE)	50,000	5,000	5,000
TLD's will be used for monitoring gamma and high-energy, beta-emitting radioisotopes, such as ³² P, ⁵¹ Cr, and ¹²⁵ I. The Radiation Safety Office may use radiation dosimeters to monitor levels of radiation in laboratories or other areas.			

New dose quantities were incorporated in the 10 CFR 20 law “Standards for Protection Against Radiation” which took effect on 1/1/94. Notice that each of the following quantities are types of dose equivalents. The following definitions describe the new quantities. (Note: the types of doses are quantities; the units used for these quantities are the rem or the Sievert (Sv).

DE: Dose Equivalent. The product of the absorbed dose in tissue, quality factor and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and Sievert.

CDE: Committed Dose Equivalent. Means the dose equivalent to organs or tissues of reference that will be received from an intake of radioactive materials, by an individual during the 50 year period following the intake.

EDE: Effective Dose Equivalent. It is the sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

CEDE: Committed Effective Dose Equivalent. It is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

DDE: Deep Dose Equivalent. Applies to external whole-body exposure. It is the dose equivalent at a tissue depth of 1 centimeter (1000 mg/cm²).

TODE: Total Organ Dose Equivalent. The sum of the CDE and DDE for the maximally exposed organ.

SDE: Shallow Dose Equivalent. Applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm²), averaged over an area of 1 square centimeter.

LDE: Lens of Eye Dose Equivalent. Applies to the external exposure of the lens of the eye and is taken as the dose equivalent at tissue depth of 0.3 centimeter (300 mg/cm²).

TEDE: Total Effective Dose Equivalent. The sum of the deep dose equivalent (for external exposures) and the committed dose equivalent (for internal exposures).

An accurate record of an employee's radiation exposure history must be maintained in the Radiation Safety Office. Employees must provide information regarding any prior occupational radiation exposure on **Previous Radiation History Data Sheet**. If a worker is occupationally exposed to radiation elsewhere, in addition to being exposed at MSC, the Authorized User should report this to the Radiation Safety Office so that an accurate record of the worker's total radiation exposure can be maintained.

Radiation detection dosimeters are not assigned for investigators who work with certain radionuclides, since the energies are beneath the detection limit of the badge. This is not a risk to the worker, however, because these types of radiation are not penetrating enough to cause a deep radiation dose. Examples of these radionuclides are ³H, ¹⁴C, ³⁵S, ⁴⁵Ca, ³³P and ⁶³Ni.

For those individuals who use X-ray equipment and/or high energy beta or gamma emitters, extremity badges (ring), should be used in conjunction with the whole body dosimeter. It is a legal requirement that workers handling greater than or equal to 1 mCi of ³²P must wear

extremity badges. The whole body badge should be worn on the torso with the name tag facing the suspected source of radiation. With finger ring badges, the name tag must face the radiation source.

Employees must wear dosimeters recommended by the Radiation Safety Office while working in any restricted area (see Glossary). While not being worn, dosimeters should be stored away from all radiation sources in a desk drawer or in some other location where they will not be exposed to excessive heat, sunlight, or moisture (for example, never leave in a car). They should not be worn outside MSC premises. Individuals who do not work directly with radioisotopes but work in a laboratory where radioisotopes are used could submit a request for dosimeters.

NOTE: Individuals who wear radiation badges should review their radiation dosimetry records to ascertain their radiation exposures in the radiation laboratory.

Lost or misplaced badges should be reported immediately to the Radiation Safety Office and a report must be handed in order to receive a replacement (**Radiation Film Badge Report Form**). Under no circumstances should workers wear a dosimeter belonging to another individual. It is a legal requirement that doses be tracked for the worker to whom the dosimeter is assigned.

Any dosimeter contaminated or exposed to heat, moisture, or medical x-rays should be returned to the Radiation Safety Office for replacement. After any accident or if an overexposure is suspected, the dosimeters should be returned immediately to the Radiation Safety Office to be read. Dosimeters should be worn on a shirt, coat pocket, lapel, or in some other position between the waist and the shoulders that will be representative of any radiation exposure. If, during a radiological process, a hand might receive a dose, a ring dosimeter should be worn on a finger of the hand under the glove.

When both whole-body and hand doses occur, two dosimeters will be issued, one for the whole body and one for hand use.

Authorized Users are responsible for distributing and collecting dosimeters for laboratory personnel under their authorization. Ring and whole-body dosimeters will be exchanged quarterly through the Radiation Safety Office. The Radiation Safety Office will keep a record of any dose received and will send each worker a copy of his or her exposure record upon request.

When terminating employment at the MSC, badges must be returned to the Radiation Safety Office and with the corresponding request (**Request for Termination Form**). If badges are not returned and proper notification of termination of employment/study has not occurred, this falls as non compliance with regulatory requirements. A termination report will be supplied when a worker leaves, since the next place of employment must be supplied with this report before the individual is allowed to work with radioactive materials.

At any time, individuals can contact the Radiation Safety Office for their dosimeter data. It typically takes 4 to 6 weeks to have the badges sent off and processed. The badge vendor will call the Radiation Safety Office to report any doses that are significantly higher than normal (i.e.,

greater than 200 mrem on a badge), and the worker will be notified. If you suspect that you have received a significant exposure, contact the Radiation Safety Office immediately. Potential exposure will be evaluated, and the badge may be sent immediately for an emergency reading. Another badge will be issued for the interim period. On an emergency basis, results can be obtained within a few days.

Maximum Permissible Doses -- Federal limits for radiation doses are provided in Table 2; however, all doses must be maintained ALARA.

The maximum permissible dose for persons under 18 years of age is 10 percent of the doses shown in Table 2. At the MSC, employees under 18 years of age are not allowed to use radioactive materials.* Exposure to pregnant women must be controlled so that the fetus will not receive more than 500 mrem during the entire gestation period. The Radiation Safety Office must be informed of any pregnant employees who may be exposed to radiation. The Radiation Safety Office through the RSC and the RSO shall take any action deemed necessary to protect these employees without affecting their employment status.

Internal exposures must be prevented. Work procedures and equipment must be designed to prevent the release of any radioactive substance into room air. Processes that involve volatile or gaseous material or that generate particulates must be confined to an approved fume hood operating with a face velocity of at least 100 fpm or to an approved glove box. Air flow rates on all hoods should be monitored and calibrated at least annually. Uncalibrated hoods should be timely reported to the Radiation Safety Office.

Minors Working With Radioactive Materials:

Radiation exposure limits for minors, (individuals under 18 years of age) who work with radioactive materials:* these limits are 10% of all of the occupational limits for adult radiation workers. For these workers, safety training must be completed prior to work with radioactive materials as with other occupational workers. It is university policy that a parental consent form must be completed and kept on file for liability purposes and risk management.

Due to university policy and legal requirements, Authorized Users must notify the Radiation Safety Office before allowing minors to handle radioactive materials. The Radiation Safety Office will assist with documentation.

Exposure Limits for the General Public:

Visitors to a radiation laboratory who are not classified as radiation workers by their employers, laboratory workers who are not trained in radiation safety, custodial staff, and any other non-radiation workers are all members of the general public under the law. They must not receive a radiation dose in excess of either:

1. 2 mrem in any one hour.
2. 100 mrem in any one year.

Since most radiation use facilities frequently have members of the general public visit their work areas, MSC has elected to maintain unrestricted area contamination limits as part of the ALARA program.

L. RADIATION EXPOSURE DURING PREGNANCY

A special situation arises when a radiation worker becomes pregnant. Under these conditions, radiation exposure could also involve exposure to the embryo or fetus. A number of studies have indicated that the embryo or fetus is more sensitive than the adult, particularly during the first four months of pregnancy. This can be a problem since many workers are unaware of their pregnancy during the first month or two of gestation. Hence, the NRC requires that all occupationally exposed workers be instructed concerning the potential health protection problems associated with prenatal radiation exposure.

Declared pregnant workers (DPW) will be assigned two badges, one for the whole body, normally worn on the torso and one for the fetus, normally worn on the abdomen. The badges will be exchanged on a monthly basis. Exposures must be maintained beneath a cap of 50 mrem per month in order to prevent exposure spikes.

Employees who become pregnant are strongly encouraged to notify her supervisor and the RSO in writing as soon as possible. A description of predicted usage of radionuclides and procedures to be performed during the gestation period should be sent to the RSC and the RSO for evaluation. The RSC and the RSO will inform the pregnant woman and her supervisor of individual actions that may need to be taken to ensure compliance with the 500 mrem rule, i.e. the fetus will not receive more than 500 mrem during the entire gestation period. Medical documentation of pregnancy is not required unless modification of assignment is necessary. If desired, confirmation of pregnancy may be obtained free of charge, through the MSC Occupational Health Clinic. If notification is not made in writing, the radiation exposure limits remain at the occupational level, that is, 5 rem per year. An individual may "un-declare" her pregnancy at any time, but this also should be documented.

ALARA recommendations on pregnancy and radiation exposure include:

1. Notifying of supervisor immediately when pregnancy is known or suspected.
2. Wearing a lead apron while performing work with certain radionuclides.
3. Using extra shielding such as lead-lined waste containers for gamma emitters.
4. Wearing radiation badges (worn at the waist) to be read monthly, not quarterly;
5. Deferring the receipt of unshielded stocks of radionuclides.
6. Leaving work area where more than one millicurie of certain radionuclides are being used.

The 500 mrem value for the fetus does not create a basis for discrimination and should be achieved in conformance with the provision of Title VII of the Civil Rights Act of 1964, as amended, regarding discrimination in employment practices, including hiring; discharge; compensation; and terms, conditions, or privileges of employment.

M. LABORATORY SUPPLIES AND EQUIPMENT



It is each principal investigator's responsibility to provide adequate shielding and monitoring instruments for use with their radioactive material and to ensure adherence to the following regulations by themselves and by all other persons working with their material. The Radiation Safety Office will provide adequate information to the principal investigator in order to maintain in compliance with the requirements of the NRC and the Broad Scope License of the University of Puerto Rico.

In addition, it is each applicant's responsibility to ensure they have access to a functional fume hood for use of volatile radioactive material. The Radiation Safety Office must be notified when fume hoods used in radioactive material experiments become nonfunctional and should be notified prior to service calls for clogged sinks, nonfunctioning hoods, or filter changes.

The following supplies and equipment are recommended for laboratories where radioisotopes are used:

1. Fume hood with minimum flow rate of 100 linear feet per minute (lfm) (if volatile radioactive solutions are used).
2. Shielding, transparent, acrylic beta shields, acrylic boxes or lead bricks, when necessary.
3. Laboratory coats, disposable gloves, and protective eyeglasses.
4. Remote pipetting devices and aerosol resistant tips. Preferably, at least one set of pipettes dedicated for radioisotope usage only.
5. Absorbent paper with impervious plastic backing for work areas.
6. Appropriate personnel monitoring badges and finger rings.
7. Appropriate signs and labels for doors, centrifuges, incubators, freezers, refrigerators, hoods, glassware, and other containers holding radioactive substances.
8. Lockable waste containers.
9. Plastic bags (i.e., not "Biohazard") are for radioactive waste disposal.
10. Lockable isotope storage boxes which can be properly secured to refrigerator or freezer.
11. Laboratory record book for maintaining inventories and surveys.
12. Copy of the MSC Radiation Safety Manual.
13. Appropriate, calibrated survey meters and materials for conducting wipe tests.
14. Supplies for keeping the area clean and free of contamination.
15. Posted current NRC Form 3.
16. Clearly labeled spill kit in each room where radioisotopes are used.

N. BIOASSAY

Some laboratory exposures to radiation may occur by the inhalation, ingestion, or skin absorption of radioactive material and may result in internal radiation exposures, which are measured by bioassay methods. These methods look for radioactivity in either the entire body (whole-body count monitoring) or in particular organs or body fluids (such as thyroid count monitoring and urine specimen radioassays).

Since the principles of external protection, i.e. time, distance, and shielding are not applicable, safety measures should be implemented to prevent internal radiation exposures. Work procedures and equipment must be designed to prevent the release of any radioactive substance into room air. Processes that involve volatile or gaseous material or that generate particulates must be confined to an approved fume hood operating with a face velocity of at least 100 fpm, or to an approved glove box. Air flow rates on all hoods must be monitored and calibrated annually through the Radiation Safety Office; uncalibrated hoods should be reported to the Radiation Safety Office.

Tritium -- Individuals involved in operations that use tritium (^3H) in any form other than metallic foil (as in gas chromatography detectors) that are in quantities greater than those listed in Table 3 below must have bioassays performed. Authorized Users must inform the Radiation Safety Office about any workers whose exposure requires periodic bioassay based on these guidelines.

Bioassays for tritium are obtained by urine samples. A baseline sample should be obtained before work with tritium is started. An employee working with quantities exceeding those shown in the table during a single operation shall provide a urine sample within one week after the exposure. An employee who, in one month, works with quantities exceeding those shown in the table shall provide urine samples weekly during the exposure and once after the exposure ends. The Radiation Safety Office may also require urine samples at other times.

Table 3. Bioassay Levels for Tritium

Bioassay Levels for Tritium			
Processing Done	Tritiated Water or Tritiated Compounds (Ci)	Tritium Gas in Sealed Vessels (Ci)	Tritiated Water Mixed with More Than 10 kg of Inert Water or Other Substances (Ci/kg)
In open room with possible escape of tritium	0.01 (10 MilliCuries)	10	0.001
Within fume hood of adequate design	0.10 (100 milliCuries)	100	0.010
Within glove boxes	1.00 (1000 milliCuries)	1000	0.100

Tritium oxides (HTO) can be absorbed into the body through the lungs or through the skin; therefore, unsealed sources of tritium should be used only in a certified fume hood. Employees should wear two pairs of protective gloves when working with tritium. Gloves should be changed frequently to prevent the tritium from penetrating over time.

Metal systems should be used when possible to reduce breakage and diffusion through stopcock grease. Laboratory equipment used to process tritium should be considered contaminated. If accidental exposure to tritium occurs, the Radiation Safety Office must be informed immediately. A urine sample or samples from the employee(s) involved must be provided as requested.

Iodine-125 and Iodine 131 -- Employees must undergo thyroid monitoring if in one operation or over a 3-month period, they handle open forms of ^{125}I or ^{131}I in quantities which exceed those given in Table 4. For a single operation, monitoring should be done 6 to 72 hours after the exposure; for ongoing exposure to radioiodine, quarterly monitoring is required.

New employees must have baseline thyroid counts measured before beginning work with ^{125}I or ^{131}I . Thyroid monitoring shall also be done when an employee's work with the quantities of radioiodine listed below is completed. Persons whose only radioiodine exposure is through the use of commercial RIA kits should refer to the second column in Table 3 to determine if they need monitoring.

Table 4. Bioassay Levels for ^{125}I and ^{131}I

Bioassay Levels for ^{125}I and ^{131}I		
	Forms	
Processing Done	Volatile or Dispersible(millicurie)	Bound to a Nonvolatile Agent(millicurie)
In open room or bench with possible escape from process vessels	0.1	1.0
Within fume hood of adequate design, but with possible escape of iodine	1.0	10.0
Within glove boxes, but with possible leakage or box contamination	10.0	100.0

Bioassay requirements for other nuclides (e.g. ^{32}P) will be determined on a case-by-case basis for those individuals who are likely to receive an intake in excess of 10 percent of the applicable annual limit on intake.

O. LABELING

**Definitions:**

Restricted area -- An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

Unrestricted area -- An area access which is neither limited nor controlled by the licensee.

Radiation area -- An area accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

High-radiation area -- An area accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. NOTE: Such an area is unlikely to be created at CDC. The establishment of such an area requires approval by the RSC and the RSO only after a thorough investigation has been made of the need for and the safety of such an area.

Airborne radioactivity area -- A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations -
(1) In excess of the derived air concentrations (DACs) specified in 10 CFR 20.1001-20.2401, or
(2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

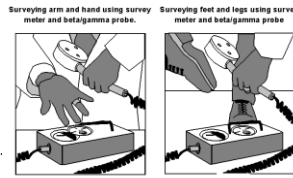
Labeling Requirements -- Each area or laboratory used to store or contain licensed radioactive material shall be conspicuously posted with a door sign bearing the radiation caution symbol and the words "Caution (or Danger), Radioactive Materials." Containers or areas where radioactive material are stored, used and disposed of shall bear a durable, clearly visible label that identifies the contents. The label must have the radiation symbol and the words "Caution (or Danger), Radioactive Materials." Beakers, test tubes, and other glassware that contain radioactive material transiently during an experiment need not be individually labeled. However, containers that will be left unattended must be labeled.

Refrigerators and other containers or areas where radioactive materials are stored must be marked with a radioactive materials label.

A current NRC 3 form "Notice to Employees," must be posted so that it can be easily seen by persons entering or leaving a restricted area. Also names and emergency phone numbers of personnel of the Radiation Safety Office, RSO and Chairperson of the RSC must be posted. Authorized Users are responsible for posting all signs required and/or provided by the Radiation Safety Office. Authorized Users must also remove signs that are no longer needed or that have become incorrect or inappropriate for their laboratories.

P. SURVEYS

Radiation Surveys:



The frequency of surveys depends on the specific protective facilities, equipment, and procedures that are designed to protect the worker and members of the public from external exposure to radiation. While the regulations do not specify a specific survey frequency, MSC is required to ensure that the dose rate limits are not exceeded.

Surveys should be sufficient to identify areas of contamination that might result in doses to workers or to the public. Combined removable and fixed contamination should be surveyed using appropriate radiation detection equipment. Removable contamination can be detected and measured through a wipe test of the surface, which is counted in an appropriate counting instrument, such as a liquid scintillation counter, a sodium iodide or germanium gamma counter, or a proportional alpha/beta counter.

Contamination surveys should be performed:

- To evaluate radioactive contamination that could be present on surfaces of floors, walls, laboratory furniture, and equipment
- After each experiment, any spill or contamination event
- When procedures or processes have changed
- To evaluate the potential contamination of users and the immediate work area, at the end of the day or prior to leaving the area of use, when licensed material is used
- In unrestricted areas at frequencies consistent with the types and quantities of materials in use but generally not less frequently than quarterly
- In areas adjacent to restricted areas and in all areas through which licensed materials are transferred and temporarily stored before shipment.

Personnel should survey for contamination in locations where individuals are working with an unsealed form of radioactive material. These surveys should be done at a frequency appropriate to the types and quantities of radioactive materials in use. By doing this, the potential for exposures can be evaluated and reduced, if necessary. Records of these surveys must be maintained for review.

The Radiation Safety Office will make independent surveys of all active radioisotope labs monthly. Such things as inventory assessment, contamination control, personnel monitoring, training and waste disposal practices will be addressed during these surveys.

Copies of the results of surveys will be forwarded to the AU, and a recheck may be conducted in the event problems have been detected that need corrective action. The RSC may accompany the Radiation Safety Office on surveys as deemed necessary for problem laboratories or for purposes of auditing the radiation safety program.

When removable radioactivity is found, the area must be decontaminated and then re-surveyed and documented. Detectable levels of removable contamination should be removed, and non-

removable contamination should be labeled and shielded whenever possible in order to maintain ALARA limits.

It is understood that certain areas may be routinely contaminated, such as internal parts of equipment and the inside areas of glassware, and that it may not be practical to decontaminate these surfaces. If this occurs, signs must be posted and protective clothing and gloves should be used when in contact with these areas. In some cases, such as ^{32}P contaminated equipment, shielding is required.

Contamination found in unrestricted areas should be immediately decontaminated to background levels. When it is not possible to get to background levels, the AU must ensure that the amounts of contamination on equipment do not exceed the contamination levels listed in the first table below (taken from Appendix Q to NUREG-1556, Vol. 7, "Program-Specific Guidance About Academic, Research and Development, and Other Licenses of Limited Scope," dated December 1999).

If the contamination is found on building surfaces, the AU must ensure that the amounts of contamination do not exceed the contamination levels listed in the second table below (taken from Appendix Q to NUREG-1556, Vol. 7, "Program-Specific Guidance About Academic, Research and Development, and Other Licenses of Limited Scope," dated December 1999). Radioactive contamination found at or above these levels must be decontaminated or shielded and labeled. (Therefore, one of the advantages of using disposable lab paper on the benches is that one only has to dispose of the contaminated area of the paper in the radioactive waste, rather than decontaminating or shielding.)

Table 5. Acceptable Surface Contamination Levels for Equipment

Nuclide	Average	Maximum	Removable
I-125, I-129	100 dpm/100 cm ²	300 dpm/100 cm ²	20 dpm/100 cm ²
I-126, I-131, I-133, Sr-90	1,000 dpm/100 cm ²	3,000 dpm/100 cm ²	200 dpm/100 cm ²
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm/100 cm ²	15,000 dpm/100 cm ²	1,000 dpm/100 cm ²

Table 6. Screening Values for Building Surface Contamination

Radionuclide	Symbol	Screening levels for unrestricted release (dpm/100 cm ²)
Hydrogen-3 (Tritium)	H-3	1.2×10^8
Carbon-14	C-14	3.7×10^6
Sodium-22	Na-22	9.5×10^3
Sulfur-35	S-35	1.3×10^7
Chlorine-36	Cl-36	5.0×10^5

Manganese-54	Mn-54	3.2×10^4
Iron-55	Fe-55	4.5×10^6
Cobalt-60	Co-60	7.1×10^3
Nickel-63	Ni-63	1.8×10^6
Strontium-90	Sr-90	8.7×10^3
Technetium-99	Tc-99	1.3×10^6
Iodine-129	I-129	3.5×10^4
Cesium-137	Cs-137	2.8×10^4
Iridium-192	Ir-192	7.4×10^4

The tables are not inclusive of all radionuclides, and specifically do not include values for radionuclides that emit alpha particles. The NRC staff is assessing current screening approaches for alpha emitters. The NRC is encouraging the use of site-specific dose assessment based on actual site physical and environmental conditions in the interim period.

Most of the radioisotope use areas on campus are treated as restricted areas, and are characterized as locations with controlled access and have proper radiation safety controls in place. Contamination limits for surveys are the controlled and unrestricted area limits, due to the ALARA programs required of licensees.

Contamination Limits:

a. Acceptable Limits:

1. Radiation levels in unrestricted areas shall not exceed 2mRem in any one – hour or 100 mRem in any one-year. If such areas are found, action shall be taken to eliminate the excessive exposure levels. Additional shielding or relocation of radioactive material may be required.
2. Radiation levels in restricted areas do not apply as personnel are monitored to determine their exposure. Individuals such as housekeeping staff who are not monitored will not be allowed to enter such areas unless a responsible person is present to monitor and limit their activities. Radiation levels shall be reduced to as low as reasonably achievable (ALARA). Radiation Safety staff will assist users and provide advice in achieving this goal.

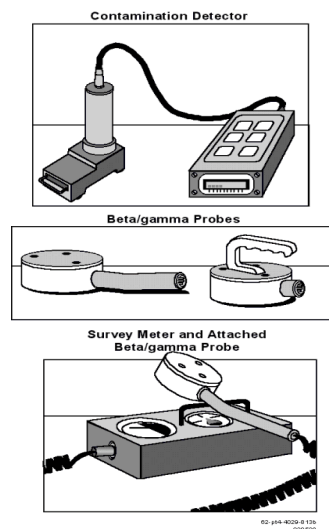
b. Contamination Limits:

1. If the survey meter readings equal or exceed three times background, the area shall be cleaned until the contamination has been removed or stabilized. Establish background for your laboratory by taking a measurement in an area where radioactive material is not used or stored.
2. If the wipe samples equal to three times background or exceed 2200 DPM/100 square centimeters (which ever is less) for beta and gamma radiation, the area shall be cleaned until the contamination has been removed or stabilized. Establish background for your lab by taking a wipe in areas where radioactive material is not used or stored. This wipe should correspond to the same items (floor vs floor, bench top vs bench top) and not different items (floor vs bench top).

- c. Unrestricted area:**
 –Alpha emitters: 200 dpm 100 cm²
 –Beta emitters: 2,000 dpm 100 cm²
- d. Restricted areas:**
 –Alpha emitters: 2,000 dpm 100 cm²
 –Beta emitters: 20,000 dpm 100 cm²
- e. Personal clothing worn outside restricted area**
 –Alpha emitters: 200 dpm 100 cm²
 –Beta emitters: 2,000 dpm 100 cm²
- f. Protective clothing worn only in restricted areas:**
 –Alpha emitters: 2,000 dpm 100 cm²
 –Beta emitters: 20,000 dpm 100 cm²
- g. Skin:**
 –Alpha emitters: 2,000 dpm 100 cm²
 –Beta emitters: 20,000 dpm 100 cm²

It is recommended that when samples or surveys reveal an easily detectable amount of activity above background, these areas should be cleaned to remove all radioactive contamination. This action should help prevent the spread of contamination and ingestion of radioactive material by personnel whose hands or clothing could become contaminated.

Q. SURVEY INSTRUMENTS



Geiger-Müller (G-M) Detector:

Principal investigators using 1 mCi or more of C-14, Na-22, P-32, P-33, S-35, Cl-36, Ca-45, Cr-51, Zn-65, Rb-86, Nb-95, Tc-99m, or I-123 at any one time are required to have a working

survey instrument with a thin-end window or pancake Geiger-Mueller probe in the laboratory at all times. Principal investigators using 1 mCi or more of I-125 at any one time are required to have a working survey instrument with a low energy sodium iodide crystal probe in the laboratory at all times.

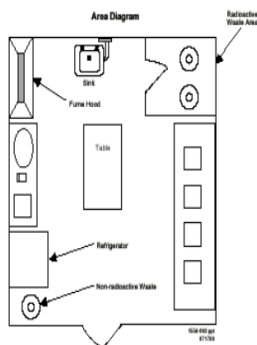
Survey instruments in use must be returned to either Radiation Safety Office or the manufacturer for recalibration on an annual basis. When a new survey instrument is purchased, a copy of the manufacturer's calibration certificate must be sent to Radiation Safety Office.

A report of malfunctioning of survey instrument will be sent from the Radiation Safety Office to the principal investigator. This instrument should be returned to the manufacturer for repair and recalibration. A copy of the manufacturer's calibration certificate must be sent to Radiation Safety Office.

A battery check should be performed each day an instrument is used. If the battery test falls below the battery condition line, the instrument must be taken out of use until the batteries are replaced.

Effective June 1, 1997 an instrument operational check must be performed with a dedicated check source each day an instrument is used. The reading taken must fall within the range limits stated on the side of the instrument. If the reading falls outside the stated range, the instrument must be taken out of use and Radiation Safety Office must be contacted.

R. MONITORING OPERATIONS INVOLVING RADIOACTIVE MATERIALS



Surveying for contamination must be made by the user with a survey meter, or equivalent procedure, at the end of the day when radioactive material has been used. Particular attention should be directed to the hands, shoe soles, lab coats, working surfaces, and the floor in the working area. Due to the potential for contamination of work areas during use of unsealed radioactive materials, it is necessary to monitor as much as possible the operations performed. Work areas should be checked before use to determine background or prior contamination. The survey instrument should be turned on and placed proximal to the work area in order to check radiation levels, and to alarm the worker if radiation levels rise significantly. Hands should be checked frequently for presence of contamination due to splashing or aerosols. At the end of the use of the work area, or each day, work areas should be monitored to determine

the presence of contamination. Note that worker clothing and shoes should also be monitored. If contamination is found, the area or equipment must be decontaminated.

Active radiation laboratories where radioactive materials are used will be surveyed by Authorized Users or their designee at end of the day by using wipes or a suitable survey meter. A survey using an instrument such as a GM counter is acceptable as long as it is sensitive enough to detect the nuclides used. For low-energy beta emitters such as ^3H or ^{14}C , contamination surveys should be conducted using wipes, which are counted using a LSC and the results must be documented in the corresponding log book in units of dpm. Users working with Na-22, P-32, P-33, S-35, Cl-36, Ca-45, Cr-51, Zn-65, Rb-86, Nb-95, Tc-99m, or I-123 must survey with a thin-end window or pancake Geiger- Müller (G-M) detector and also a wipe test should be performed. Users working with I-125 must survey with a sodium iodide scintillation detector. For ^{125}I , a survey instrument equipped with a low-energy sodium iodide crystal is to be used or wipes may be counted on a gamma counter.

Surveys must be documented with one of the standardized survey forms provided by Radiation Safety Office. The entries on either survey form must show the areas surveyed the date of the survey, the radiation measurements in their correct units, the instrument used and the corresponding model and serial number, decontamination results with the correct units, and the initials of the person or persons performing the survey. This must be documented in the daily journal work sheet and must be available and actualized for the monthly inspections that the Radiation Safety Office personnel performed. The results of laboratory surveys will be recorded **on Daily Radiation Survey Report Sheet.**

A diagram of the laboratory should be made, showing benches, desks, sinks and hoods; each area tested should be numbered. The wipes or counts from survey instruments should be numbered according to this diagram so that any area that becomes contaminated can be readily identified. Areas tested should be representative of where contamination might be expected (e.g, hoods, sinks, and counter tops), as well as some areas where contamination would not be expected.

In addition to routine surveys, laboratories or other potentially contaminated areas must be surveyed:

1. After any spill, leak, fire, or other disturbance in a laboratory.
2. When work with radioactive materials is terminated.
3. Before and after laboratory construction modifications.
4. Before maintenance or removal of any equipment that may have come in contact with radioactive material or that contains radioactive material.

The Radiation Safety Office personnel will do their routine monthly inspections to all the laboratories that uses, manages and dispose radioactive materials. They will also be performing a survey with a GM and a wipe test for any contamination. The results will be documented in a monthly survey report in units of mR/hr or dpm and available at the Radiation Safety Office.

Laboratories with sealed sources will be surveyed at least biannually. The following sealed sources will be surveyed by the laboratorians, with OHS assistance, for leakage and external contamination at least once every 6 months. The sources will also be surveyed before and after

they are moved within a laboratory or to another laboratory, after being dropped or otherwise damaged, and before and after maintenance:

NOTE: Maintenance, repair, cleaning, replacement, and disposal of GC foils contained in detector cells shall be performed "only" by the device manufacturer. Transfer of GC units or foils off site or on site must be coordinated through the Radiation Safety Section.

Table 7. Laboratory Surveillance Frequency

Survey Category	Activity Range	Survey Frequency
Very Low	<0.01 mCi	Once a month
Low	0.01 mCi to 1 mCi	Every 2 weeks (Or more frequently at the discretion of the Authorized User)
Medium	>1 mCi to 10 mCi	After each operation
High	> 10 mCi	After each operation
Modifying Factors		*Factors
Simple storage		x 0.01
Very simple wet operations (e.g., dilutions of stock solutions, RIA's done with kits)		x 0.1
Normal chemical operations (e.g., in vitro viral, bacterial, or cell labeling and simple analysis, such as by gel electrophoresis or counting in gamma - or beta counters)		x 1
Complex wet operations (e.g., radiolabeling of nucleic acids, proteins, etc.:in vitro viral, bacterial, or cell labeling and complex analysis, such as zonal centrifugation or extractions)		x 10
Simple dry operations (e.g., manipulation of powders) and work with volatile radioactive compounds (e.g., I-125)		x 10
Exposure of nonoccupational persons		x 10

*The objective is to determine how often to survey the laboratory. To do this, multiply the number of milliCuries of isotope actually used by the appropriate modifying factor to determine the applicable activity range for purposes of surveillance frequency.

EXAMPLE 1: A protein is to be labeled with 1.5 mCi I-125. The modifying factor of 10 multiplied by 1.5 mCi equals 15 mCi or the activity range > 10 mCi. The factor 10 comes from the procedure being classified as a complex wet operation or being classified as work with volatile radioactive compounds. Thus, the laboratory should be surveyed immediately after the labeling procedure.

ALSO NOTE: The laboratorian performing the procedure with I-125 must have a thyroid scan after the operation if the conditions so indicate this (see Table 7).

EXAMPLE 2: An in vivo labeled virus preparation containing 500 uCi H-3 uridine to be purified by large-scale separation in a zonal or continuous flow rotor with a rotating seal assembly. This is classified as a complex wet operation. Multiply the number of milliCuries actually used (0.5)

by the modifying factor 10 gives an activity range of 5 mCi. This value falls within the 1 mCi to 10 mCi range requiring a survey be performed after each operation with the radioisotope.

Any instrument used for surveys must be calibrated for the specific radioisotope in question at least annually. Calibration curves and records of calibration will be available for all instruments used by radiation workers and OHS. When necessary, the OHS will supply survey instruments to Authorized Users for monitoring radiological procedures.

Action levels for decontamination are shown in Table 8.

**Table 8. Actions Levels for Decontamination
Beta and Gamma Emitters**

Smear Results	Action
100 dpm/100cm ²	No action required by RSO. Left to discretion of Authorized User.
100-350 dpm/100 cm ²	Area or surfaces should be cleaned as soon as possible by the Authorized User or laboratory personnel. Shoe covers and step-off pads shall be used if contamination is on floor.
350-2,000 dpm/100 cm ²	Contamination should be cleaned immediately under supervision of OHS. Shoe covers and step-off pads are required for entry into area. Only essential personnel will have access.
2,000 dpm/100 cm ²	Air flow should be shut off. Entry of personnel into area should be prevented until a representative of OHS arrives. Cleanup should begin immediately by Authorized user under supervision of RSO. Shoe covers and step-off pads are required.
cm ² = square centimeters (100 cm ² = 4"x 4")	

Cleanup must be undertaken by Authorized Users or laboratory personnel, not by custodial workers.

Every month, the Radiation Safety Office personnel will perform surveys of laboratories that use radioactive materials as a quality control measure. The Authorized User designee is responsible for making laboratories or other areas accessible for surveys by the Radiation Safety Office.

S. RADIOACTIVE WASTE DISPOSAL

At MSC all disposal of radioactive waste must be authorized by the RSO. All radioactive waste shall be separated from non-radioactive waste. All radioactive waste must be collected for proper disposal. Contact the Radiation Safety Office for radioactive waste pickup arrangements.

The issue of radioactive waste disposal is very complex, due not only to the radioactive nature of the waste and its inherent disposal problems, but also the recent concerns with the chemical hazards associated with the same waste. Hence, it is possible to have mixed waste, which contains not only radioactive waste, but RCRA (Resource Conservation and Recovery Act)

hazardous chemical waste. Some liquid scintillation fluids are an example, because they contain toluene or benzene, which is hazardous under the RCRA laws, due to flammability and toxicity. Consequently, radioactive waste must be properly manifested for the isotope and activity, and any other hazardous constituents, including chemical or biohazardous components.

Consult with the Radiation Safety Office when planning your research. It may not be economically reasonable to do certain experiments due to the associated waste disposal costs.

Radioactive waste is any waste that contains or is contaminated with radioactive material. This includes liquids, solids, animals, used scintillation counting liquids (LSC) etc. Consult with the Radiation Safety Office in the early planning stages of experiments to develop waste minimization strategies and discuss waste disposal procedures.

Radioactive waste must never be placed in any non-radioactive waste container. The RSO will not approve any disposal of radioactive waste thru the sink. No general (non-radioactive) waste may be disposed of in radioactive waste containers. Radioactive waste must never be placed in the corridor or any public areas.

All radioactive waste must be labeled with the appropriate label (Radioactive Waste Label) stating the radioisotope name, activity, date of disposal, and the Radiation Worker's full name and telephone number according to NRC law . Tags must be completely filled out at all times after any radioactive waste is placed in the designated storage area in the lab. All individual plastic containers, scintillation vials, bags and bottles of radioactive waste must be tagged with this label. Bench top waste containers are considered part of the experiment, and must be labeled with the isotope, activity in dpm or μCi , and the date.

Records of radioactive waste disposal must be maintained by the University for NRC review, so this labeling is critical. A Radioactive Waste Disposal Log should be used to compile a list of the radioisotopes disposed of in the waste cans.

It is the responsibility of the Principal Investigator to supply primary and secondary containers to prevent the waste from leaking or contaminating surfaces. All radioactive waste must be stored in appropriate containers until its disposal, and the integrity of the waste containers must be assured. All radioactive waste must be secured against unauthorized access or removal. Laboratories must supply their own shielding for waste that may cause external exposures to workers in the area. In order to dispose of waste under the current regulatory constraints, it is necessary to segregate all radioisotopes from each other (except ^3H and ^{14}C), and to segregate chemically hazardous waste from other radioactive waste. It is prudent that workers only place waste which is actually contaminated with radiation in the radioactive waste containers to control waste disposal cost.

All radioactive waste containers must be locked and secured. Consult with the Radiation Safety Office to obtain appropriate lockable waste and waste storage containers.

Radioactive waste pickup must be scheduled by calling the Radiation Safety Office or sending an e-mail requesting the service. The following information is needed to schedule a pickup:

1. Name of Radiation Worker and phone number.
2. Location of waste (building and laboratory number).
3. Type of waste (liquid, solid, carcasses, LSC vials, etc.).

4. Radionuclide(s) in waste.
5. Any special handling instructions.

The Radiation Safety Office will assist Authorized Users in obtaining an appropriate radioactive waste storage container for each isotope used in the laboratory. Each waste container will be used for disposal of ONE radioisotope ONLY, except for dual labeled radioisotope experiments. Disposal procedures for these containers will be based on the longest half-life. The radioactive waste cans should be stored in an area within the laboratory where they will not be knocked over, used for other waste, or accidentally mistaken as cans for non-radioactive waste. Authorized Users and Radiation Workers are responsible for securing waste until the Radiation Safety Office removes it.

Disposal of Radioactive Waste:

Due to the problems in radioactive waste management and legal requirements, no radioactive waste may be removed from the laboratory without the complete information on the tag. Chronic failure to thoroughly manifest radioactive waste may result in suspension of permission to use radioactive materials. MSC currently manages radioactive waste by one or more of the following methods as directed by the Radiation Safety Office:

1. Decay-in-storage (DIS)
2. Transfer to an authorized recipient

1. Procedure for disposal by Decay-In-Storage (DIS):

- Only short-lived waste (physical half-life of less than or equal to 90 days) may be disposed of by DIS.
- Short-lived waste should be segregated from long-lived waste (half-life greater than 90 days) at the source.
- Waste should be stored in suitable well-marked containers, and the containers should provide adequate shielding.
- Liquid and solid wastes must be stored separately.
- When the container is full, it should be sealed. The sealed container should be identified with a label affixed or attached to it.
- Contact the Radiation Safety Office for waste pickup.
- The contents of the container should be allowed to decay for at least 10 half-lives of the longest-lived radioisotope in the container.
- Prior to disposal as ordinary trash, each container should be monitored as follows:
 - Check the radiation detection survey meter for proper operation.
 - Survey the contents of each container in a low background area.
 - Remove any shielding from around the container.
 - Monitor all surfaces of the container.
 - Discard the contents as ordinary trash only if the surveys of the contents indicate no residual radioactivity, i.e. surface readings are indistinguishable from background.
 - All radioactivity labels must be defaced or removed from containers and packages prior to disposal in ordinary (non-radioactive) waste. If waste is

compacted, all labels that are visible in the compacted mass must be defaced or removed.

- If the surveys indicate residual radioactivity, return the container to the DIS area.
- If the surveys indicate no residual radioactivity, record the date when the container was sealed, the disposal date, type of waste (used or unused material, gloves, etc.), survey instrument used, and the initials of the individual performing surveys and disposing of the waste.

2. Procedure for disposal by transfer to an authorized recipient:

- The Radiation Safety Office is responsible for finding an appropriate company for waste disposal.

Quantifying Levels of Radioactivity in Waste:

Radioactive and other hazardous materials must be completely manifested in the waste. In order to accurately list levels of radioactivity on the tags, it is necessary to assess the levels which are disposed in both liquid and solid waste. Suggestions on methods to quantify the waste follow.

1. During a given experiment it is known that a certain quantity of radionuclide is used. At the end of each of several similar experiments, take a sample of liquid waste and count it with the appropriate counting equipment (LSC). The activity in the sample per unit volume is then multiplied by the total volume of the liquid waste generated. For the solid waste, the quantity of radioactivity in the liquid is subtracted from the total quantity used in the experiment, and the remainder is then the quantity in the solid waste.

Example:

Total Used in Experiment (corrected for age): 500 μCi

Liquid Sample Volume: 1 ml

Total Liquid Waste Volume: 4000 ml

Activity in Liquid Waste Sample: $8 \text{ E-}2 \mu\text{Ci/ml}$

Liquid Waste Total Activity: $8 \text{ E-}2 \mu\text{Ci/ml} \times 4000 \text{ ml} = 320 \mu\text{Ci}$ in liquid waste

Solid Waste Total Activity: $500 \mu\text{Ci} - 320 \mu\text{Ci} = 180 \mu\text{Ci}$ in solid waste

2. After the first few experiments, or when the waste carboy is full, take a sample of the pooled liquid waste, and count it as above. Multiply the activity of the sample per unit volume by the total volume in the carboy to obtain the total activity in the carboy. Quantify the solid waste as above by subtracting the liquid waste activity.

Multi-hazard Waste --This is waste that contains any combination of radioactive, biohazardous, and chemically-hazardous materials known as mixed waste. **Avoid creating such materials, if possible!** Disposal of multi-hazard-waste is extremely costly and difficult.

Solid Waste -- This includes test tubes, beakers, absorbent paper, gloves, pipettes, and other dry items contaminated with radioactive material but not containing liquid radioactive waste. This material must be placed in plastic bags, sealed with tape. Hypodermic needles, capillary

pipettes, and other sharp objects must be placed in puncture-proof containers before being put into the large waste cans.

Containers bearing a radioactive label, but no longer containing radioactive material must be disposed of as ordinary waste only after the radioactive label is defaced or removed and after being decontaminated.

Before any radioactive material contaminated with a microbiological organism (virus, fungus, or bacteria) is disposed, it must be chemically treated in a manner that destroys all living organisms (e.g., with fresh 10 percent bleach solution). Autoclaving or Gamma cell irradiation should be used only when necessary. Care should be taken to protect autoclaves from any radioactive contamination, particularly, tritium, and radioiodines.

Before animal experiments with radioisotopes can begin, animal protocols must be approved by the Animal Use Committee (IACUC) and the Radiation Safety Office must be consulted so that proper arrangements can be made for disposal of radiologically contaminated or infectious carcasses. Animals that contain less than 0.05 microcurie of ^3H or ^{14}C per gram can be disposed of as biological waste. At concentrations higher than this or for other radioisotopes, the animal or tissues must be disposed of as radioactive waste.

Organic Liquid Waste -- Scintillation vials that contain less than 0.05 microcurie of ^3H or ^{14}C per gram of scintillation medium should be disposed of as chemical waste and not as radioactive waste. All scintillation vials containing radioactivity above these levels must be labeled as radioactive waste. Scintillation fluid and radioactive waste must be left in the original vials for disposal. These vials should be placed upright in shipping trays rather than in the large waste cans or plastic bags. Organic solvents that are insoluble, flammable, or toxic must be collected in inert, airtight plastic bottles and must never be disposed thru the sink. The RSO shall oversee the disposal of any aqueous liquid waste that will be picked up from radiation laboratories by Radiation Safety Staff or their representative.

Aqueous Liquid Waste -- No liquid radioactive waste shall be disposed of by the sewage system.

The sink must always be a point of survey when performing decontamination lab surveys.

Liquid radioactive waste must be stored in appropriate containers. RIA kits containing ^{125}I should be treated as radioactive waste and will be disposed of by the Radiation Safety Office.

T. LEAK TEST OF SEALED SOURCES

Leak tests will be performed at the intervals approved by NRC or an Agreement State. Leak tests will be performed by personnel of the Radiation Safety Office according to the sealed source or plated foil manufacturers (distributors) and kit supplier's instructions. As an alternative, we will implement the model leak test program published in Appendix R to NUREG-1556, Vol. 7, "Consolidated Guidance about Materials Licenses: Program-Specific Guidance About Academic, Research and Development, and Other Licensees of Limited Scope" dated December 1999.

The Radiation Safety Officer shall ensure that leak tests and physical inventories are performed on those sealed sources specified and at the intervals specified in the applicable radioactive material license condition or applicable regulations.

The responsible Authorized User shall ensure that:

1. the Radiation Safety Officer is notified prior to the acquisition, transfer, relocation, loss, destruction or disposal of any sealed source;
2. all sealed sources under the Authorized User's control are secured against unauthorized access or removal;
3. a complete inventory of all sealed sources under the Authorized User's control is maintained and kept available for inspection by Radiation Safety.

This program is as follows:

- For each source to be tested, list identifying information such as manufacturer, model number, serial number, radionuclides, and activity.
- If available, use a survey meter to monitor exposure.
- Prepare a separate wipe sample (e.g., cotton swab or filter paper) for each source.
- Number each wipe to correlate with identifying information for each source.
- Wipe the most accessible area (but not directly from the surface of a source) where contamination would accumulate if the sealed source were leaking.
- Select an instrument that is sensitive enough to detect 185 becquerels (0.005 microcurie) of the radionuclides and ensure that its calibration is current.
- Using the selected instrument, count and record background count rate.
- Calculate efficiency.
- Count each wipe sample; determine net count rate.
- For each sample, calculate and record estimated activity in becquerels (or microcuries).
- Sign and date the list of sources, data and calculations. Retain records for 3 years (10 CFR 20.2103(a) "Records of Surveys").
- If the wipe test activity is 185 Bq (0.005 μ Ci) or greater, notify the RSO, so that the source can be withdrawn from use and disposed of properly.

The sealed and foil source(s) shall be tested for leakage and/or contamination at intervals not to exceed 6 months. Any source received from another person which is not accompanied by a certificate indicating that a test was performed within 6 months before the transfer shall not be put into use until tested.

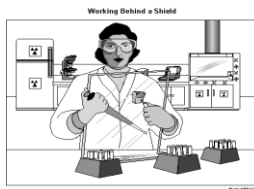
Notwithstanding the periodic leak test required by this condition, any licensed sealed source is exempt from such leak tests when the source contains 100 microcuries or less of beta and/or gamma emitting material or 10 microcuries or less of alpha emitting material.

Any source in storage which has not been used needs to be tested every ten years. When the source is removed from storage for use or transfer to another person, it shall be tested before use or transfer.

The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. If the test reveals the presence of 0.005 microcurie or more of removable contamination, the source shall be removed from service and decontaminated, repaired, or

disposed of in accordance with NRC regulations. A report shall be filed within 5 days of the date the leak test result is known with the NRC. The report shall specify the source involved, the test results, and corrective action taken. Records of leak test results shall be kept in units of microcuries and shall be maintained for inspection by the NRC. Records may be disposed of following NRC inspection.

U. RADIATION SAFETY RULES



1. Eating, drinking, smoking, and the application of cosmetics are prohibited in a room where radioactive materials are used or stored.
2. Protective gloves shall be worn when handling contaminated or potentially contaminated items.
3. Pipetting radioactive solutions by mouth is prohibited.
4. Persons with open wounds should be particularly careful when working with radioactive materials (the wound should be properly covered).
5. Disposable absorbent pads and remote handling devices shall be utilized whenever possible.
6. Hands should be washed thoroughly after handling radioactive materials, especially before eating.
7. Food items shall not be stored in areas or equipment designated for radioactive materials.
8. Personnel monitoring badges shall be worn in restricted areas, as applicable.
9. Radioactive waste shall be kept in labeled containers.
10. Stock shipments shall be handled and stored in specially designated locations.
11. Good housekeeping shall be maintained at all times. Contamination/spills shall be cleaned up immediately.
12. Follow the established emergency procedures in the case of an accident.
13. Conduct radiation meter surveys after each use and wipe test surveys frequently (document at least monthly). When measurements are abnormal, find the cause and correct.
14. When using volatile radionuclides (e.g. iodine) or heating radioactive solutions, always perform work in a properly operating fume hood.
15. Transport radioactive materials in such a manner as to prevent spillage or breakage and ensure adequate shielding.
16. Label all containers of radioactive materials, including radionuclide, amount and date. All containers except those in immediate use must be labeled.
17. Utilize shielding when necessary to maintain radiation levels as low as reasonably achievable (ALARA).
18. Store radioactive material in locked cabinets/refrigerators or keep the laboratory door locked when lab personnel are not present.

V. CLEAN LABORATORY CONDITIONS AND CONTAINMENT

Good housekeeping is an important component of laboratory safety. Sloppy work habits, incorrect procedures or shortcuts, lack of containment, crowded or cluttered work areas and similar situations may cause or contribute to accidents or contamination. The following practices will assist in maintaining effective safety.

1. Maintain neat and clean work areas. Clutter, debris and crowded conditions interfere with the careful handling required in hazardous materials use.
2. Follow experimental procedures carefully. Radioisotope approvals are contingent upon following the procedures, statements and representations made in the Authorized User's approval. Departures from the procedures may place the approval in jeopardy.
3. Use absorbent poly-backed laboratory paper, with the plastic side down, to protect surfaces from inadvertent spills or splashes. Laboratory benches, fume hoods, trays containing samples, waste areas and floors in the radioactive work areas are some of the locations where absorbent paper is useful.
4. Use secondary containment for all radioactive solutions, samples, liquid waste or any other hazardous materials which may be spilled. Use trays, boxes, bus trays and other types of secondary containment to catch spills, splashes and possible container ruptures.
5. When transporting radioactive materials, use a cart; this will prevent accidentally dropping or tipping the container.
6. Clean up the work areas and survey for contamination after work is finished. If contamination is present, decontaminate or dispose of the contaminated materials.
7. Use tightly sealed or capped containers when moving, heating, centrifuging or vortexing. Spills, evaporation, gases, container breakage or splashes may occur in any procedure where energy is put into the system.
8. Label all radioactive materials and areas where radioactive materials are used, stored or disposed.
9. Identify a specific area in the freezer or refrigerator with radioactive labels where radioactive material will be stored. The surface of the plastic containers with the stock solution inside should be identified with radioactive symbols and should be visible at all times. The freezer or refrigerator should be well organized for inspections.

Housekeeping:

Because supervision of general or shared facilities is usually limited or lacking, responsibility for the condition of the room and its equipment is the responsibility of the principal investigator. The exception is the floor care, which custodians do periodically. Laboratory personnel should keep the rooms well organized and clean. Custodial personnel should not clean floors without the approval from the principal investigator. The principal investigator must arrange times that both is convenient for the laboratory staff and not hazardous to the custodians. All chemicals,

biological, and radioactive materials must be secured from being accidentally disturbed or relocated by the custodians.

- Do not order more supplies than are actually needed. Do not use the floor as a storage area for supplies.
- Laboratory personnel are responsible for cleaning up spills of hazardous materials from counters and floors and picking up razor blades, pipette tips, and other sharps from the floor before allowing the custodians to sweep, mop, or refinish the floors.
- If items need to be moved, the laboratory personnel must move the items to allow the custodians to perform their duties.

Maintenance personnel:

They should only enter laboratories when laboratory staff is present. All possible hazards must be removed from the area before any particular work is performed. Contact the Laboratory Safety Office if items contain a chemical, biological, or radioactive hazard prior to the start of work.

W. RADIONUCLIDE USE INVOLVING ANIMALS

Before allowing an individual to care for animals used in studies with or treated with licensed material, the Radiation Safety Officer (RSO), Authorized User (AU), and/or veterinarian must ensure that he or she has sufficient training and experience to maintain ALARA doses, control contamination, handle waste appropriately, etc.

The principal investigator, under whose application the material is obtained, is responsible for posting each cage with a sign bearing the standard radiation caution sign, radionuclide, total activity in each animal, date and name of experimenter. In order to minimize the spread of contamination, animals used in studies with or treated with licensed material should be housed in cages or stalls separate from other animals. The facilities, stalls, or cages shall be secured to prevent unauthorized access to the animals. Individuals caring for these animals should reduce the chance of personal contamination by wearing gloves, lab coats, and eye protection, appropriately. They should monitor themselves before leaving the area, particularly their hands and the soles of their shoes. Lab personnel are responsible for conducting area surveys after experiments as prescribed in the laboratory survey section.

Principal investigators and authorized personnel must have access to rooms housing animals injected with radioactive material. Animal housing facilities for animals containing radioactive materials must be locked at all times.

Special care should be observed when cleaning the cage or stall. The cage or stall, the bedding, and waste from the animal may contain radioactive material. Animal Care Facilities, cages, animal carcasses, waste, bedding/excreta, and related equipment must be held by the investigative staff until the Radiation Safety Office has surveyed for release to the Animal Resource Staff.

Disposal of laboratory animals that contain radioactive material require special procedures. Animal carcasses that contain less than 1.85 kBq/gram (0.05 micro curies/gram) of carbon-14, or hydrogen-3 may be disposed of by the same method as non-radioactive animal carcasses. Animal carcasses that contain byproduct material with a half-life of less than 120 days may be allowed to decay-in-storage in a freezer dedicated for radioactive material. Animal carcasses must be held for a minimum of 10 half-lives of the longest lived isotope. After 10 half-lives, the animal carcasses may be disposed as non-radioactive, if radiation surveys (performed in a low background area and without any interposed shielding) of the carcasses at the end of the holding period indicate that radiation levels are indistinguishable from background.

Investigative staff may be issued additional protection and control instructions from the Animal Resource Committee, Radiation Safety Committee and/or the Radiation Safety Office. The Research Group will be required to follow these instructions.

Research Animal Approval:

The administration of radioactive material to research animals and the irradiation of research animals must be approved by the Institutional Animal Care Use Committee (IACUC) and the Radiation Safety Committee.

General Policies:

1. Injection of radioactive material into animals, when appropriate, shall be performed in trays lined with absorbent material.
2. Cages must be labeled as to radionuclide, quantity of radionuclide administered per animal, date of administration, and authorized user.
3. Special procedures must be developed in relation to the collection and disposition of the animal's excreta and carcass.
4. Any live animals containing radioactive material being returned to the Vivarium shall have prior approval of the Division of Laboratory Animal Resources and the Radiation Safety Officer.

Part 2. Emergency Procedures

I. Role of the Radiation Safety Office:

The Radiation Safety Office will investigate all accident, spills, fires, or other incidents in which radiological material is involved. In the event of an accident, the Radiation Safety Office will assist by providing technical advice and by monitoring personnel.

The Radiation Safety Office, through the Radiation Safety Officer (RSO), the Radiation Safety Committee, and the Occupational Health Clinic (CASSO), have the responsibility to plan and arrange emergency medical care for victims contaminated with radioactive material or overexposed to radiation at MSC facilities. The Radiation Safety Office will ensure that

procedures for emergency care, a list of telephone numbers, and contacts are made available to all Authorized Users.

II. General Emergency Procedures:

All users of radioactive materials should be familiar with these procedures before any emergency arises. When an accident involving radioactive materials occurs, address the greatest hazard first. Lifesaving measures always take precedence over decontamination or other concerns. Advise personnel working nearby of any hazard or accident as soon as possible and prevent them entering the hazardous area. In case of an incident or accident notify the Office of Laboratory Safety in Research and RSO immediately at telephones:

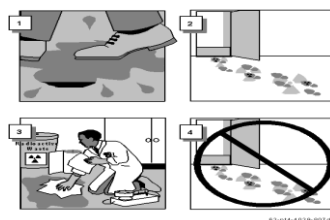
RSO direct line (787) 766-3062;

Office for Laboratory Safety in Research: 1687, 1688, Occupational Health Officers)

III. Specific Emergency Procedures:

A. Spills

Handling Radioactive Incidents/Emergencies:



Incidents may occur during the use of radioactive materials, such as spills, accidental releases into the air, contamination of the worker or the work area, and numerous other possible problems. When an incident occurs, the worker must first make a judgment as to whether the incident is a minor incident, major incident or emergency. Subsequent actions are based on this decision.

A minor incident with radioactive materials is an abnormal occurrence involving low amounts of radioactive materials, where the worker handling the spill knows how to clean it up, has the decontamination materials on hand, and can respond without incurring risk of exposures or spreading within a reasonably short time. Notify the RSO promptly for assistance at (787) 772-8300, X-1302.

A major incident is an abnormal occurrence involving high amounts of radioactive materials, high risk nuclides, large contaminated areas, contamination of the skin, airborne radioactivity, or any situation where contamination may have been spread outside the authorized area. Major spills must be reported to the RSO or his/her designee immediately, as required by federal law. Call the RSO during working hours at (787) 772-8300, X-1302; dial 911 during non working hours.

An emergency is an incident which involves serious injury or death, fire, explosion, or significant release of a health or life threatening material, which is or may be coupled with a minor or major radiological incident. **DIAL 911 ON A CAMPUS PHONE IMMEDIATELY IF AN EMERGENCY HAS OCCURRED!!**

In the event of an **EMERGENCY** in which radioactive materials are involved, the following procedure should be instituted:

1. Notify all persons in the area that an EMERGENCY has occurred and evacuate the area if a risk to all personnel present exists.
2. Dial 7911 on a campus phone and NOTIFY the nature of emergency, using the reporting guidelines previously listed in this section.
3. AWAIT THE EMERGENCY RESPONDERS who will assist and provide direction, as well as contact any other necessary responders.
4. Allow no one to return to work in the area unless approved by the RSO.

All incidents involving radioactive materials must be reported as soon as possible to the Authorized User. If the Authorized User is not available, notify the RSO, who will advise and assist with the problem. The provisions for responding to spills and other contamination events must cover any unique properties of accelerator-produced radionuclides or discrete sources of Ra-226 that the applicant possesses. These radioactive materials are now included in the definition of byproduct material as a result of the EPAct. When producing PET radioactive drugs, the procedures should also address spills or loss of control of curie quantities of material.

Model Spill/Contamination Procedures – Low- and High-Dose Unsealed Sources (this now includes spills of and contamination from accelerator-produced radioactive materials or unsealed discrete sources of radium-226)

This model provides acceptable procedures for responding to medical use emergencies. This model meets the requirements of 10 CFR 20.1101.

In the event of a **MINOR SPILL Spills of Liquids and Solids (this now includes spills of or contamination from accelerator-produced radioactive materials or discrete sources of radium-226)**, these procedures should be followed:

1. Notify the Authorized User and persons in the area that an incident has occurred.
2. Put on protective clothing, such as shoe covers, a lab coat and booties and gloves before starting containment and clean up of the spill using the absorbent paper.
3. Contain the spill. Cover with absorbent paper or dike with absorbent. Paper should be dampened if solids are spilled.
4. Carefully fold the absorbent paper with the clean side out and place in a bag labeled "caution radioactive material" for transfer to a radioactive waste container. Also put contaminated gloves and any other contaminated disposable material in the bag.
4. Isolate the area to prevent unnecessary spread and personnel exposures.
5. Survey using the appropriate monitoring equipment in order to evaluate the presence of contamination on an individual's skin and clothing and on lab equipment. If skin or clothing contamination is present, a major spill has occurred. Have someone who is not contaminated call the Radiation Safety Office immediately.

6. To localize the contamination, wipe inward toward the center of the spill.
7. Using disposable gloves carefully fold up the absorbent paper and pad and deposit in an appropriate bag labeled "caution radioactive material" for transfer to a radioactive waste container. Also put contaminated gloves and any other contaminated disposable material in the bag.
8. Survey the area with a low-range radiation detection survey instrument sufficiently sensitive to detect the radionuclide. Check for removable contamination to ensure contamination levels are below trigger levels. Check the area around the spill to determine the extent.
9. Decontaminate the spill using decontaminant detergent (available from RSO), and resurvey.
10. Continue step #8 until the area is decontaminated completely.
11. If you leave the contaminated area, remove your gloves, shoes, and laboratory coat; segregate them as radioactive waste before leaving the laboratory.
12. After removing protective clothing, wash all contaminated areas of skin thoroughly, without vigorous scrubbing, with cool water and mild soap for five to ten minutes. Do this as soon as possible after the accident. Be careful not to contaminate yourself after you have thoroughly washed.
13. Document spill in radiation survey log book.
14. Notify the RSO promptly and report the incident to the RSO.
15. Allow no one to return to work in the area unless approved by the RSO.

In the event of a **MAJOR SPILL of Liquids and Solids (this now includes spills of or contamination from accelerator-produced radioactive materials or discrete sources of radium-226)**, the following procedures should be instituted:

1. Notify all persons in the area that a major spill or incident has occurred and vacate unnecessary personnel from the room. Notify the Authorized User.
2. If possible, prevent the spreading of the radioactive material by using absorbent paper. Paper should be dampened if solids are spilled. Do not attempt to clean it up. To prevent the spread of contamination, clearly indicate the boundaries of the spill and limit the movement of all personnel who may be contaminated.
3. Shield the source if possible. Do this only if it can be done without further contamination or a significant increase in radiation exposure.
4. Close the room and lock or otherwise secure the area to prevent entry. Post the room with a sign to warn anyone trying to enter that a spill of radioactive material has occurred. Attempt to prevent further contamination or spreading to unrestricted areas. (Hallways, non-radiation laboratories, etc., are unrestricted areas.)
5. Notify the RSO immediately if the spill occurs during normal work hours. Call MSC Police, 911 on a campus phone, after normal working hours.
6. Remove all contaminated clothing and awaits instructions concerning cleanup from the RSO.
7. If skin contamination has occurred, measure levels of contamination with a survey meter, record, and begin decontamination by gentle washing with warm water and mild soap, washing downwards towards extremities, not upwards. If contamination remains, the RSO may consider inducing perspiration. Then wash the affected area again to remove any contamination that was released by the perspiration.
8. Allow no one to return to work in the area unless approved by the RSO.

Table N.1 is general guidance to determine whether a major spill/contamination procedure or a minor spill/contamination procedure will be implemented. All spills/contaminations of radium-226 will be considered major spills. Estimate the amount of radioactivity spilled. Initiate a major or minor spill/contamination procedure, based on the following information. Spills above these mCi amounts are considered major, and below these levels are considered minor. Spills involving curie quantities of PET radionuclides should initially be considered major spills; either downgrade to a minor spill after decay or restrict access pending complete decay.

Table N.1 Relative Hazards of Common Radionuclides			
RADIONUCLIDE	MILLICURIE	RADIONUCLIDE	MILLICURIE
P-32	1	Tc-99m	100
Cr-51	100	In-111	10
Co-57	10	I-123	10
Co-58	10	I-125	1
Fe-59	1	I-131	1
Co-60	1	Sm-153	10
Ga-67	10	Yb-169	10
Se-75	1	Hg-197	10
Sr-85	10	Au-198	10
Sr-89	1	Tl-201	100

Estimate the amount of radioactivity spilled. Initiate a major or minor spill/contamination procedure, based on the following information. Spills above these mCi amounts are considered major, and below these levels are considered minor. Spills involving curie quantities of PET radionuclides should initially be considered major spills; either downgrade to a minor spill after decay or restrict access pending complete decay.

B. *Methods of Decontamination*



Spill/Contamination Kit

Assemble a spill/contamination kit that may contain the following items:

- Disposable gloves and housekeeping gloves,
- Disposable lab coats,
- Disposable head coverings,
- Disposable shoe covers,
- Roll of absorbent paper with plastic backing,
- Masking tape,
- Plastic trash bags with twist ties,

- “Radioactive Material” labeling tape,
- Marking pen,
- Pre-strung “Radioactive Material” labeling tags,
- Contamination wipes,
- Instructions for “Emergency Procedures,”
- Clipboard with copy of Radioactive Spill Report Form,
- Pencil, and
- Appropriate survey instruments, including batteries.

Liquid Radioactive Decontaminant: Concentrated liquid decontaminating agents are available from most scientific suppliers. This detergent is diluted with water and rapidly and easily cleans radioactive contamination without excessive effort. Mild wiping or scrubbing will remove most contamination using this detergent. Note that these detergents contain a carcinogen, so the Material Safety Data Sheet should be read by new radiation users so that they are aware of the hazards. In dilute liquid form, radioactive decontaminants do not present a significant hazard to handlers unless ingested or splashed in eyes. Avoid prolonged skin contact with the concentrated material.

Foam Spray Decontaminant: A variety of foam spray decontamination products are available which are marketed as radioactive decontaminants. However, many other foam cleaning products accomplish decontamination just as effectively at a much lower cost; most of these are marketed in any store as bathroom or kitchen cleaning agents. Spray the foam on the contaminated areas, let sit for a few minutes then wipe off with a dry paper towel.

Other Decontaminating Agents: Many other agents will work to clean radioactive contamination that has been resistant to the above methods. Contact the RSO for assistance with difficult to remove contamination. He/she will help identify a method of decontamination which will work for your particular surface, nuclide, chemical form and location. Depending on these factors, effective solutions to the problem will be identified.

Contamination on Skin: Use lukewarm (not hot or cold) water and a mild cleaning agent, such as soap. Do not rub hard or scrub with abrasives, which may break the surface of the skin. Clean the affected area in a downwards fashion, with the grain of the skin and hair, not against it, and towards the tips of extremities, not upwards. Check the area after gentle drying. If still contaminated, use a cream hand cleaner which contains no abrasives. Remember to notify the RSO immediately if personnel contamination occurs or is suspected. Also, note the readings of radioactive contamination detected with the survey instrument and the times that it was discovered and then removed.

C. Emergency Surgery of Patients Who Have Received Therapeutic Amounts of Radionuclides (this now includes therapeutic amounts of accelerator-produced radioactive materials or any discrete sources of radium-226)

The following procedures should be followed:

1. If emergency surgery is performed within the first 24 hours following the administration of I-131 sodium iodide, fluids (e.g., blood, urine) will be carefully removed and contained in a closed system.

2. Protective eye wear will be worn by the surgeon and any personnel involved in the surgical procedure for protection of the eyes from possible splashing of radioactive material and exposure from beta radiation (if applicable).
3. The radiation safety staff will direct personnel in methods to keep doses ALARA during surgical procedures.
4. If an injury occurs during surgery that results in a cut or tear in the glove used, the individual involved will be monitored to determine if radioactive material was introduced into the wound. The RSO will be informed of any possible radiation hazard.

D. Autopsy of Patients Who Have Received Therapeutic Amounts of Radionuclides (this now includes therapeutic amounts of accelerator-produced radioactive materials or any discrete sources of radium-226)

The following procedures should be followed:

1. Immediately notify the AU in charge of the patient and the RSO upon death of a therapy patient.
2. An autopsy will be performed only after consultation and permission from the RSO. Radiation safety staff should evaluate the radiation hazard(s), direct personnel in safety and protection, and suggest suitable procedures in order to keep doses ALARA during the autopsy.
3. Protective eye wear should be worn by the pathologist and assisting staff for protection from possible splashing of radioactive material. Consider the need for protection against exposure from high-energy beta rays in cases involving therapy with P-32 and Y-90.
4. Remove tissues containing large activities early to help reduce exposure of autopsy personnel. Shield and dispose of contaminated tissues in accord with license conditions. In some cases, exposure reduction may be accomplished by removing tissues for dissection to a location where the exposure rate is lower.
5. If an injury occurs during the autopsy that results in a cut or tear in the glove, monitor the wound and decontaminate as appropriate to the situation; inform radiation safety staff.

References: NRC Report No. 111, "Developing Radiation Emergency Plans for Academic,

Medical, and Industrial Facilities,” 1991, contains helpful information. It is available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Suite 400, Bethesda, Maryland 20814-3095. NCRP’s telephone numbers are: (301) 657-2652
1-800-229-2652.

C. *Fire*

1. Use the following emergency telephone numbers:

Fire Department:

- a. For any fire involving serious injuries, call 7-911. Do not delay. Tell the dispatcher that radioactive material is involved.
 - b. Business hours, and after hours, call the Security Control Room at telephone (787) 758-2525, ext. 1000. The control room will call 7-911.
 - c. Business hours, call the Radiation Safety Office at (787) 758-2525, ext. 1687, 1688.
 - d. Business hours, call the Radiation Safety Office direct line (787) 766-3062.
 - e.
2. Call the Radiation Safety Office.
 3. Try to extinguish the fire without risking the safety of personnel.
 4. Avoid spreading the contamination.
 5. Do not continue work in the laboratory without Radiation Safety Office approval.
 6. Again, call 7-911 without delay for any serious injuries. Give as much information as possible regarding the nature of the accident and the injuries that are present. Do not hang up the phone until you are instructed to do so.

D. *Explosion*

1. **For any accident involving serious injuries, first call 7-911. Do not delay.** Inform the dispatcher that the accident involves radioactive material.
2. Perform any lifesaving and first-aid measure that you can. There may be a significant amount of time before the Hazardous Material (HAZMAT) unit of the Emergency Medical System can get to the accident.
3. Use the following emergency telephone numbers:

Security Control Room of MSC

- a. Call the Security Control Room at telephone (787) 758-2525, ext. 1000.
 - b. Call the Radiation Safety Office (787) 758-2525, ext. 1687 and 1688.
 - c. Call the Occupational Health Clinic (787) 758-2525, ext. 2910, 2911, 2913.
4. Turn off all fume hoods and ventilation where possible.

5. If possible, evacuate the area of the explosion. Restrict contamination to the area by removing your gloves, shoes, and laboratory coats before leaving.
6. Wash all contaminated areas of skin thoroughly, without vigorous scrubbing, with cool water and mild soap for five to ten minutes. Do this as soon as possible after the accident.
7. Flush any superficial wound thoroughly with cool water and cover with a sterile dressing.
8. Remember also to remove all clothing that may have been contaminated.
9. Do not leave the area or go to the OHC until someone from the OHS has determined that you have been successfully decontaminated.

E. Accidents Involving Large Sources

1. If there is any reason to suspect that a large source such as the gamma-cell is unshielded or leaking in any way, you should immediately evacuate all personnel to a safe area.
2. Call the MSC Security Control Room at telephone (787) 758-2525, ext. 1000 and call Radiation Safety Office at telephone (787) 758-2525, ext. 1687 and 1688 or the direct line (787) 766-3062.

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11. 8.35 Planned Special Exposures, 1992. (Draft DG-8008 published 12/1991).
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14. 10.11 Guide for the preparation of applications for radiation safety evaluation and registration of sealed sources containing by-product material, 1987. (Draft FC 603-4 published 12/1986).
15. Appendix X Guidance on complying with new part 20 requirements, 1992.
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Appendices

A. Radiation Protection Dose Standards:

Radiation Dose Limits to Adult Radiation Workers:

- 5,000 mrem (50 mSv) per year total effective dose equivalent to the whole body, no one organ of which may exceed 50,000 mrem (500 mSv) per year.
- 15,000 mrem (150 mSv) per year to the lens of the eye
- 50,000 mrem (500 mSv) per year to the skin or to any extremities (hands and forearms, or feet and ankles)

Radiation Dose Limits to Minor (under age 18) Radiation Workers:

- 500 mrem (5 mSv) per year total effective dose equivalent to the whole body, no one organ of which may exceed 5,000 mrem (50 mSv) per year.
- 1500 mrem (15 mSv) per year to the lens of the eye
- 5000 mrem (50 mSv) per year to the skin or to any extremities (hands and forearms, or feet and ankles)

Radiation Dose Limits to Members of the General Public:

- 100 mrem (1 mSv) per year total effective dose equivalent to the whole body
- 2 mrem (0.02 mSv) total effective dose equivalent to the whole body per hour
- 500 mrem (5 mSv) total effective dose equivalent to the fetus of a Declared Pregnant Woman per gestation

B. Radiation Safety Due Dates:

ACTIVITY	DATE DUE
RADIOISTOPE INVENTORY REPORT	Monthly
RADIATION SURVEY REPORT	Monthly
RADIATION BADGES DISTRIBUTED & COLLECTED	15 JAN 15 APR 15 JUL 15 OCT
GAS CHROMATORGRAPH WIPE TESTS	1 FEB 1 AUG
RADIATION METER CALIBRATION	ONCE/YEAR
EACH RADIATION WORKER SHOULD FORWARD THE REPORT(S) THROUGH HIS/HER AUTHORIZED USER TO THE RADIATION SAFETY OFFICE	

C. Record Keeping:



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The requirements for maintaining records such as: decommissioning records, surveys, including the type of information required. All licensees are required to maintain these records in an identified location until the site is released for unrestricted use. In the event that the licensed activities are transferred to another person or entity, these records shall be transferred to the new licensee prior to transfer of the licensed activities. The new licensee is responsible for maintaining these records until the license is terminated. When the license is terminated, these records shall be transferred to NRC.

Radiation Protection Program:

Implementation and audits – 3 years
 Receipts of radioactive material – 3 years
 Transfer of radioactive material – 3 years
 Misadministration – 5 years
 Dosage records – 3 years
 Refresher courses – 3 years

Surveys:

Surveys meters and calibrations – 3 years
 Surveys and Wipe test – 3 years
 Leak test – 3 years
 Dosimetry reports – until license ends
 Bioassay reports – until license ends
 Air monitoring – until license ends
 Effluents reports - until license ends
 Waste disposal - until license ends
 Individual monitoring records - until license ends
 Important to decommissioning - Until the site is released for unrestricted use

D. Table of Unit Conversions:

TO CONVERT	INTO	MULTIPLY BY
atomic mass units	grams	1.66×10^{-24}
atomic mass units	mev	931.478

barns	sq cm	10^{-24}
becquerels	curies	2.7027×10^{-11}
becquerels	picuries	27.027
calories	ergs	4.184×10^7
calories	joules	4.184
curies	becquerels	3.7×10^{10}
curies	dis/sec	3.7×10^{10}
curies	dis/min	2.22×10^{12}
curies	dpm	2.22×10^{12}
curies	millicuries	10^3
curies	microcuries	10^6
curies	picocuries	10^{12}
curies	kilocuries	10^{-3}
dis/min	millicuries	4.505×10^{-10}
dis/min	microcuries	4.505×10^{-7}
dis/sec	millicuries	2.703×10^{-8}
dis/sec	microcuries	2.703×10^{-5}
ergs	joules	10^{-7}
gallons (US liq)	liters	3.785
gallons (US H ₂ O 60F))	lbs of H ₂ O	8.3282
gallons	pints (liq)	8
grams	joules/cm	9.807×10^{-5}
grams	joules/meter (newtons)	9.807×10^{-3}
grams	kilograms	0.001
grams	milligrams	1,000
gram-calories	joules	4.186
grays	rads	100
hours	days	0.04167
hours	weeks	5.952×10^{-3}
inches	centimeters	2.540
Inches	meters	0.0254
inches	millimeters	25.40
kilocuries	curies	10^3
kilograms	grams	1,000
kilograms	joules/cm	.09807
kilograms	joules/meter (newtons)	9.807

kilograms	pounds (avdp)	2.205
kilograms/cu meter	grams/cu cm	0.001
liters	cu cm	1,000
liters	gallons (US liq)	0.2642
liters	pints (US liq)	2.113
liters	quarts (US liq)	1.057
mev	ergs	1.6×10^{-6}
microcuries	dis/sec	3.700×10^4
microcuries	picocuries	1×10^6
microcuries	dis/min	2.220×10^6
millicuries	dis/sec	3.700×10^7
millicuries	dis/min	2.220×10^9
milligrams	grams	0.001
milligrams/liter	parts/million	1
milliliters	liters	0.001
millimeters	centimeters	0.1
rads	J/kg	0.01
rads	ergs/g	100
rads	MeV/cm ³ of air (stp)	8.071×10^4
rads	MeV/g	6.242×10^7
rads	grays	10^{-2}
rems	sieverts	10^{-2}
roentgen	esu/cu cm (air)	1
roentgen	ion prs/cu cm (air)	2.083×10^9
roentgen	ion prs/gm (air)	1.61×10^{12}
roentgen	mev/cu cm (air)	6.77×10^4
roentgen	mev/gm (air)	5.24×10^7
roentgen	ergs/gm (air)	83.80
roentgen	cals/gm (air)	2.0×10^{-6}
sievert	rems	100

E. Information of Radioisotopes:

TRITIUM ^3H

Radioactive half-life T
.....12.4 years

1/2:

Principal emission:18.6 keV beta
(maximum)
Monitoring for contamination:Swipes counted by liquid
scintillation
Biological Monitoring:Urine
samples
Annual Limit on Intake, ingestion or inhalation:1 x 10⁹ Bq (.
27 mCi)
(tritiated
water)
Maximum range in air:
.....6 mm
Shielding required:
.....none

Special Considerations for Open Sources:

- Tritium, because of its low beta-energy, cannot be monitored directly and therefore special care is needed to keep the working environment clean and tidy. Regular monitoring by counting swipes is advisable in areas where this nuclide is used.
- Tritium can be absorbed through the skin. Volatile compounds containing tritium, tritiated water and tritium gas should be handled in a fume hood.
- External contamination, although not causing a radiation dose itself, should be kept as low as possible as it can lead to internal and hence hazardous contamination; it can also interfere in experimental results.
- DNA precursors (*eg tritiated thymidine*) are regarded as more toxic than tritiated water partly because activity is concentrated into cell nuclei. This is reflected by lower ALI's for the material in this form.
- Bioassays may be required for handling high amounts. Consult permit.

CARBON 14 14 C

Radioactive half-life T 1/2:
.....5730 years
Principal emission:0.156 MeV beta
(maximum)
Monitoring for contamination:swipes counted by liquid
scintillation
Thin end - window Geiger-Müller
detector
Biological Monitoring:Urine samples, breath measurements
(CO₂)
Annual Limit on Intake:4 x 10⁷ Bq (.
1.1 mCi)
by inhalation or ingestion
Maximum range in air:
.....24 cm
Shielding:

1 cm Perspex/Plexiglas. Thinner Perspex/Plexiglas down to 3 mm, although adequate to reduce doses, does not have good mechanical properties. Glass containers, although not generally recommended for shielding of beta radiation, are effective for small quantities of ^{22}Na .

Special Considerations for Open Sources:

- There is a possibility that some organic compounds can be absorbed through gloves.
- Care needs to be taken not to generate carbon dioxide which could be inhaled.
- Work with volatile compounds or those likely to generate carbon monoxide or carbon dioxide in fume hood.

SODIUM-22 ^{22}Na

Radioactive	half-life	T	1/2:
		2.6 years	
Principal emission:		1.275 MeV	gamma
(maximum)			
Monitoring for contamination:		swipes counted by liquid	
scintillation			
		Thin end-window Geiger-Müller	
detector			
Biological monitoring:			Urine
samples			
Annual Limit on Intake by inhalation:		1×10^7 Bq (.	
0.27 mCi)			
Dose Rate from 37 MBq (1 mCi)			
At 1 meter	11.5 uSv/hr (1.15 mR/hr)		
Shielding:			
		Lead	
First half value layer:		6.4	
mm lead			

Special Considerations for Open Sources:

- Near an unshielded ^{22}Na source, dose rates due to positron radiation can be much higher than dose rates due to gamma radiation. Avoid direct eye exposure by interposing transparent shields or indirect viewing. Avoid skin exposure by indirect handling and prompt removal of contaminated protective clothing.
- Multiple mCi quantities need to be completely surrounded by shielding material to prevent positrons from escaping and creating secondary annihilation radiation outside the shielding.
- Wear extremity and whole body dosimeters while handling mCi (37 MBq) quantities.
- Do not work over open containers.
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels.
- Handle potentially volatile compounds in fume hoods.
- Urine sample for bioassay should be submitted at least 4 hours after handling open sources of more than 1 mCi of ^{22}Na to indicate uptake by personnel.

PHOSPHORUS 32 32 P

Radioactive	half-life	T	1/2:
.....	.....	14.3 days	.....
Principal emission:	.....	1.709 MeV	beta
(maximum)	.....	.....	.....
Monitoring for contamination:	.....	swipes counted by liquid	.....
scintillation	.....	.....	.....
.....	.....	.....	Geiger-Müller
detector	.....	.....	.....
Biological Monitoring:	.....	.....	Urine
samples	.....	.....	.....
Annual Limit on Intake (ALI) by ingestion or inhalation:	.....	1 x 10 ⁷ Bq	.....
(0.27 mCi)	.....	.....	.....
Maximum	range	in	air:
.....	.....	790 cm	.....
Dose rate from 1 MBq (27 m Ci) in 1 ml:	.....	.....	.....
210 mSv/h (21 rem/h) at surface	.....	.....	.....
2.5 μ Sv/h (0.25 mrem/h) at 1 m	.....	.....	.....
Shielding required:	.....	Plexiglas or similar plastic (at least	.....
one cm)	.....	.....	.....

Special Considerations for Open Sources:

- Phosphorus-32 is the highest energy beta emitting radionuclide commonly encountered in research laboratories and as such requires special care. Avoid exposure as much as possible (e.g. *do not hold tubes containing even small quantities of 32 P any longer than necessary - use a stand or holder*).
- If quantities greater than a few tens of MBq (1 mCi) are used, wrist or ring dosimeters must be worn. Remember wrist dosimeters alone may fail to indicate high dose to the fingertips. The use of lead-impregnated rubber gloves is also recommended.
- Even with low-density materials (for example, Perspex/Plexiglas) the absorption of the beta-particles gives rise to relatively high energy Bremsstrahlung which may require some lead shielding when quantities greater than a few hundred MBq (or tens of millicuries) are being handled.

Specific Precautions for the Handling of Phosphorus-32:

- Solutions containing more than 1 mCi (37 MBq) of 32 P or carrier-free solutions of 32 P require specific handling precautions. Carrier-free material is readily absorbed by the skin and will contribute significant doses to the bone where it is preferentially deposited. Careful handling can avoid high radiation doses to the hands while working with this material.
- Follow all general radioisotope safety precautions
- Double glove (disposable), changing the outer pair frequently during the procedure
- Plexiglas shielding should be used as shielding for all 32 P handling and must be used with quantities in excess of 1 mCi (37 MBq). The half-value layer (HVL) thickness for 32 P is 1 cm of plexiglas. Lead or other high density material may be used as secondary shielding

- Safety glasses or goggles should be used when handling ^{32}P . This will reduce the external irradiation of the eye and skin as well as prevent the high radiation doses which accompany accidental contamination by splashing
- Wrist or ring radiation dosimeters as well as whole body dosimeters must be worn if handling quantities of 1 mCi (37 MBq) or larger
- More than one person should be present during handling involving more than 1 mCi (37 MBq)
- Due to the high dose rates encountered, work should never be carried out above an open container of ^{32}P or other high energy beta emitter
- A solution of phosphate buffer is most effective in removing ^{32}P contaminations from surfaces.

PHOSPHORUS 33 ^{33}P

Radioactive	half-life	T	1/2:
.....	.....	25.4 days	
Principal emission:	.....	0.249 MeV	beta
(maximum)			
Monitoring for contamination:	.....	swipes counted by liquid	
scintillation			
		Geiger-Müller survey meter with pancake	
detector			
Biological Monitoring:	.....	Urine	
samples			
Annual Limit on Intake (ALI) by ingestion or inhalation:	.....	80 x 10 ⁶ Bq (
2 mCi)			
Maximum	range	in	air:
.....	.....	89 cm	
Dose rate from 1 MBq (27 m Ci) in 1 ml:			
30 mSv/h (3 rem/h) at surface			
3.6 μ Sv/h (0.36 mrem/h) at 1 m			
Shielding required:	.....	Plexiglas or similar plastic (at least	
one cm)			

Special Considerations for Open Sources:

- Phosphorus-33 is moderate energy beta emitting radionuclide, commonly encountered in research laboratories. Laboratory coats and gloves are the principle protection since skin dose and contamination are the primary concerns - approximately 14% of P-33 beta particles can be transmitted through the skin.
- Drying can form airborne P-33 contamination.

SULPHUR-35 ^{35}S

Radioactive	half-life	T	1/2:
.....	.....	87.4 days	
Principal emission:	.....	0.167 MeV	beta
(maximum)			

Monitoring for contamination:Swipes counted by liquid scintillation

detector

Thin end-window Geiger-Müller

Biological Monitoring:Urine samples

Annual Limit on Intake (ALI) by inhalation or ingestion: 2×10^8 Bq (.5 mCi)

Maximum range in air:26 cm

Shielding:

1 cm Perspex/Plexiglas, Thinner Perspex/Plexiglas down to 3 mm, although adequate to reduce doses, does not have good mechanical properties. Glass containers, although not generally recommended for shielding of beta radiation, are effective for small quantities of ^{35}S .

Special Considerations for Open Sources:

- Note that organic compounds are often strongly retained and no limits of exposure have been set for them.
- Be careful not to generate sulphur dioxide or hydrogen sulphide which could be inhaled.
- Radiolysis of ^{35}S -amino acids during storage and use may lead to the release of ^{35}S -labelled volatile impurities. Handle such material in fume hood. Although the level of these impurities is small (typically less than 0.05%), contamination of the internal surfaces of storage and reaction vessels may occur. Vials should be opened and used in fume hoods.

CHLORINE-36 ^{36}Cl

Radioactive half-life $T_{1/2}$: 3.01×10^5 years

Principal emission:0.710 MeV beta (maximum)

Monitoring for contamination:swipes counted by liquid scintillation

detector

Thin end-window Geiger-Müller

Biological monitoring:Urine samples

Annual Limit on Intake on inhalation: 3×10^6 Bq (.80 mCi)

Maximum range in air:2 m

Shielding:6 mm (1/4") Plexiglas

Special Considerations for Open Sources:

- ^{36}Cl beta particles have sufficient energy to penetrate gloves and skin.

- When handling millicurie (37 MBq) quantities do not work over an open container.
- Avoid glove and skin contamination or ensure that it is promptly detected and removed.
- Consider the need for shielding the ^{36}Cl with 6 mm (1/4") thick Plexiglas and wearing wrist and finger dosimeters.
- Handle potentially volatile compounds in fume hoods.
- Avoid skin exposure by using tongs and handling tools, regular monitoring and prompt removal of contaminated protective clothing.

CALCIUM-45 ^{45}Ca

Radioactive half-life T 1/2:
163 days
 Principal emissions:0.257 MeV beta
 (maximum)
 Monitoring for contamination:swipes counted by liquid
 scintillation
 End-window Geiger-Müller
 detector
 Biological Monitoring:
Urine
 Annual Limit on Intake (ALI) by inhalation (most restrictive): 1 x 10⁷ Bq (.
 0.27 mCi)
 Maximum range in air:
52 cm
 Shielding:
 1 cm Perspex/Plexiglas cuts out all betas. Glass containers, although not generally recom-
 mended for shielding of beta radiation, are effective for small quantities of ^{45}Ca .

Special Considerations for Open Sources:

- In general Calcium-45 does not require any special precautions over and above those necessary for any beta-emitting radionuclide of this energy of emissions.
- The majority of Calcium-45 is deposited in the bone: retained with a long biological half-life.

CHROMIUM-51 ^{51}Cr

Radioactive half-life T 1/2:
27.7 days
 Principal emissions:0.32 MeV
 gamma (9.8%)
 5 keV X-ray (22% V-51 K
 X-rays)
 Monitoring for contamination:swipes counted by liquid
 scintillation
 End-window Geiger-Müller
 detector

BiologicalMonitoring:
Whole body
 Annual Limit on Intake (ALI) by inhalation:7 x 10⁸ Bq (.
 20 mCi)
 Dose rate from 1 GBq (27 mCi)
 point source at 1m: 4.7 m Sv/h (0.47 mrem/h)
 First half value layer:3
 mm lead

Special Considerations for Open Sources:

- In general Chromium-51 does not require any special precautions over and above those necessary for any radionuclide of this energy of emissions.
- Chromium-51 in the form of chromate is not selectively absorbed by any organ in the body.

IRON-59 ⁵⁹Fe

Radioactivehalf-lifeT1/2:
44.6 days
 Principal emission:1.292 MeV
 gamma1.099 MeV
 gamma0.466 MeV beta
 (maximum)0.273 MeV beta
 (maximum)
 Monitoring for contamination:swipes counted by liquid
 scintillation
Thin end-window Geiger-Müller
 detector
 Biological monitoring:Urine
 samples
 Annual Limit on Intake by inhalation:5 x 10⁶ Bq (.
 0.14 mCi)
 Dose Rate from 37 MBq (1 mCi)
 At 1 meter 6.1 uSv/hr (0.61 mR/hr)
 Shielding:Lead
First half value layer:9.7
 mm lead

Special Considerations for Open Sources:

- Near an unshielded ^{59}Fe source, dose rates from beta radiation can be much higher than dose rates due to gamma radiation.
- Store ^{59}Fe behind lead shields.
- Avoid direct eye exposure by interposing transparent shields or indirect viewing.
- Urinalysis to determine uptake is only effective from 4 to 24 hours after handling ^{59}Fe .
- Wear extremity and whole body dosimeters while handling mCi (37 MBq) quantities.
- Handle potentially volatile compounds and powder in fume hoods.

NICKEL-63 ^{63}Ni

Radioactive	half-life	T	1/2:
.....	.....	100 years	
Principal emission: (maximum)		0.066 MeV beta	
Monitoring for contamination: scintillation		swipes counted by liquid	
Biological Monitoring: samples		Urine	
Annual Limit on Intake by inhalation: (0.5 mCi)		2×10^7 Bq (
Maximum	range	in	air:
.....	.....	5 cm	

Shielding:
Plexiglas/Perspex if necessary. Glass containers, although not generally recommended for shielding of beta radiation, are effective for small quantities of ^{63}Ni .

Special Considerations for Open Sources:

- Millicurie quantities of ^{63}Ni do not represent a significant external exposure hazard since the low energy betas emitted cannot penetrate the outer skin layer.
- The critical organ for ^{63}Ni is the bone. The elimination rate of ^{63}Ni depends on the chemical form. A few percent of most compounds taken into the body are eliminated via the urine.
- Handle ^{63}Ni compounds which are potentially volatile or in powder form in fume hoods.
- Many ^{63}Ni compounds cannot be detected with sufficient sensitivity by liquid scintillation counting (LSC) of small volume urine samples. If insoluble compounds are handled, 24-hour urine samples should be periodically collected and analyzed (LSC) to ensure that controls are adequate.

IODINE-125 ^{125}I

Radioactive	half-life	T	1/2:
.....	.....	59.6 days	
Principal Emissions: 35 keV gamma (7% emitted, 93% internally converted)		27-32 keV X-rays (140% Te K X-rays)	
Monitoring for contamination: scintillation		swipes counted by liquid	

Thin end-window Geiger-Müller

detector

Biological Monitoring:Thyroid scans (scintillation detector NaI)

Annual Limit on Intake (ALI) by inhalation: 2×10^6 Bq (. 55 m Ci)

Dose rate from 1 GBq point source at 1 m: 41 m Sv/h (4.1 mrem/h)

First half value layer: 0.02 mm lead

Special Considerations for Open Sources:

- Volatilization of iodine is the most significant problem with this isotope. Simply opening a vial of sodium [125I] iodide at high radioactive concentration can cause minute droplets of up to 100 Bq to become airborne. Solutions containing iodide ions should not be made acidic or stored frozen: both lead to formation of volatile elemental iodine.
- As some iodo-compounds can penetrate surgical rubber gloves, it is advisable to wear two pairs, or polythene (polyethylene) gloves over rubber.
- In the event of suspected or actual significant contamination of personnel the thyroid should be blocked by administration of stable iodine as tablets of potassium iodate (170 mg) or potassium iodide (130 mg) which are available at hospitals.
- To render any spilled iodine-125 chemically stable the area of the spill should be treated with alkaline sodium thiosulphate solution prior to commencing decontamination. Note, however, that the quantity of radioiodine in normal RIA kits (usually <3.7 MBq or 100 m Ci) is such that these can be handled safely with reasonable care on the open bench.

Specific Precautions for the Handling of Radioiodine:

- Follow all general radioisotope safety practices (Section 2.1.8)
- Users of radioiodine must participate in the thyroid bioassay program (Sect. 2.1.7)
- Background bioassay must be conducted prior to beginning use of radioiodine
- Bioassays of the thyroid must be performed within four days after radioiodine use
- Contact the RPS for information on this service
- Double glove (disposable), changing the outer pair frequently during the radioiodine procedure
- Ensure that the radioiodine container has been properly checked for leakage upon receipt
- Vials containing radioiodine should be opened only in a fume hood, and containers of radioiodine should be kept closed when not required
- Carry out all work involving volatile forms of radioiodine in a fume hood
- A properly functioning VentAlert alarm system will warn users if the fume hood does not have a proper air exhaust in the range of 100-200 linear feet per minute. Contact the RPS if there is any doubt as to the proper operation of the fume hood
- Charcoal filtration of the exhaust may be required for large quantities of radioiodine
- Direct contact with unshielded containers of radioiodine should be avoided
- Shielding material of sheet lead will reduce doses received from external gamma radiation
- Minimizing the time near radioiodine sources will reduce doses from external radiation

- Radioactive waste contaminated with volatile radioiodine should be kept in the fume hood
- Shielding may be necessary to reduce radiation fields near the waste
- Radioiodine solutions with a pH of 8 or more are less likely to produce vapours
- During the experiment and afterwards, monitor the area with appropriate detection equipment.
- A solution consisting of 0.1 M sodium iodide, 0.1 M sodium hydroxide and 0.1 M sodium thiosulphate is effective in cleaning radioiodine spills.
- Wash hands immediately following a radioiodine procedure.

Contact the Radiation Safety Office immediately in case of any emergency situation involving radioiodine or other radioactive material.

IODINE-131 131 I

Radioactive	half-life	T	1/2:
		8.04 days	
Principal Emissions:			0.365 MeV
gamma			
			0.638 MeV
gamma			
			0.606 MeV beta
(maximum)			
			0.334 MeV beta
(maximum)			
Monitoring for contamination:	swipes counted by liquid		
scintillation			
	scintillation		
detector (NaI)			
Biological Monitoring:	Thyroid scans (NaI scintillation		
detector)			
Annual Limit on Intake (ALI) by inhalation:	1 x 10 ⁶ Bq (. 27		
m Ci)			
Dose rate from 1 GBq point	76.5 m Sv/h (7.65 mrem/h)		
source at 1 m:			
First half value layer:	0.50 cm lead		

Special Considerations for Open Sources:

- Volatilization of iodine is the most significant problem with this isotope. Simply opening a vial of sodium [131I] iodide at high radioactive concentration can cause minute droplets to become airborne. Solutions containing iodide ions should not be made acidic or stored frozen: both lead to formation of volatile elemental iodine.
- As some iodo-compounds can penetrate surgical rubber gloves, it is advisable to wear two pairs or polythene (polyethylene) gloves over rubber.
- In the event of suspected or actual significant contamination of personnel, the thyroid may be blocked by administration of stable iodine as tablets of potassium iodate (170 mg) or potassium iodide (130 mg) which are available at hospitals.

- To render any spilled Iodine-131 chemically stable the area of the spill should be treated with alkaline sodium thiosulphate solution before commencing decontamination.

Specific Precautions for the Handling of Radioiodine:

- Follow all general radioisotope safety practices
- Users of radioiodine must participate in the thyroid bioassay program
- Background bioassay must be conducted prior to beginning use of radioiodine
- Bioassays of the thyroid must be performed within four days after radioiodine use
- Contact the *Radiation Safety Office* for information on this service
- Double glove (disposable), changing the outer pair frequently during the radioiodine procedure
- Ensure that the radioiodine container has been properly checked for leakage upon receipt
- Vials containing radioiodine should be opened only in a fume hood, and containers of radioiodine should be kept closed when not required
- Carry out all work involving volatile forms of radioiodine in a fume hood
- A properly functioning VentAlert alarm system will warn users if the fume hood does not have a proper air exhaust in the range of 100-200 linear feet per minute. Contact the RPS if there is any doubt as to the proper operation of the fume hood
- Charcoal filtration of the exhaust may be required for large quantities of radioiodine
- Direct contact with unshielded containers of radioiodine should be avoided
- Shielding material of sheet lead will reduce doses received from external gamma radiation
- Minimizing the time near radioiodine sources will reduce doses from external radiation
- Radioactive waste contaminated with volatile radioiodine should be kept in the fume hood
- Shielding may be necessary to reduce radiation fields near the waste
- Radioiodine solutions with a pH of 8 or more are less likely to produce vapours
- During the experiment and afterwards, monitor the area with appropriate detection equipment.
- A solution consisting of 0.1 M sodium iodide, 0.1 M sodium hydroxide and 0.1 M sodium thiosulphate is effective in cleaning radioiodine spills.
- Wash hands immediately following a radioiodine procedure.

Contact the RPS immediately in case of any emergency situation involving radioiodine or other radioactive material.

Glossary

Glossary

Absorbed dose: is the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

Activity: is the rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

Alpha particle: is a strongly ionizing particle emitted from the nucleus of an atom during radioactive decay, containing 2 protons and neutrons and having a double positive charge.

Alternate Authorized User: serves in the absence of the Authorized user and can assume any duties as assigned.

Authorized User: an employee who is approved by the RSO and RSC and is ultimately responsible for the safety of those who use radioisotopes. This under his or her supervision.

Beta particle: is an ionizing charge particle emitted from the nucleus of an atom during radioactive decay, equal in mass and charge to an electron.

Bioassay: determination of type, quantity, concentration, and, in some cases, the location of radioactive material in the human body, by direct measurement (in vivo counting) or by evaluation of materials from the human body.

Biological half-life: is the length of time required for one-half of a radioactive substance to be biologically eliminated from the body.

Bremsstrahlung: is electromagnetic (x-ray) radiation associated with the deceleration of charged particles passing through matter.

Contamination: is the deposition of radioactive material in any place where it is not wanted.

Controlled area: means an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

Counts per minute (cpm): is the number of nuclear transformations from radioactive decay that are detected by a counting instrument in one minute.

Curie (Ci): is a unit of activity equal to 37 billion disintegrations per second.

Declared pregnant woman: means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Disintegrations per minute (dpm): is the number of nuclear transformations from radioactive decay in one minute.

Dose equivalent: quantity of radiation dose on a common scale used to calculate the effective absorbed dose. The units of dose equivalent are the rem and sievert (Sv).

Dosimeter: is a device used to determine the external radiation dose a person has received.

Effective half life: is the length of time required for a radioactive substance in the body to lose one-half of its activity (by biological elimination and radioactive decay).

Exposure: means the amount of ionization in air from x-rays and gamma rays.

Extremity: means hand, elbow, arm below the elbow, foot, knee, or leg below the knee.

Gamma rays: are very penetrating electromagnetic radiations emitted from a nucleus of an atom during radioactive decay.

Half-life: is the length of time required for a radioactive substance to lose one-half of its activity by radioactive decay.

Limits (dose limits): means the permissible upper bounds of radiation doses.

Permitted worker: is a laboratory worker who does not work with radioactive materials but works in a radiation laboratory.

Photon: means a type of radiation in the form of an electromagnetic wave.

Rad: is a unit of radiation absorbed dose. One rad is equal to 100 ergs per gram.

Radioactive decay: is the spontaneous process of unstable nuclei in an atom disintegrating into stable nuclei, releasing radiation in the process.

Radiation (ionizing radiation): means particles capable of producing ions, alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other.

Radiation Workers: are those personnel listed on the Authorized User Form of the supervisor to conduct work with radioactive materials.

Radioisotope: is a radioactive nuclide of a particular element.

Rem: is a unit of dose equivalent. One rem is approximately equal to one rad of beta, gamma, or x-ray radiation, or 1/20 of alpha radiation.

Restricted area: means an area, where access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

Roentgen: is a unit of radiation exposure. One roentgen is equal to 0.00025 Coulombs of electrical charge per kilogram of air.

Thermoluminescent Dosimeter (TLD): is a dosimeter worn by radiation workers to measure their radiation dose. The TLD contains crystalline material which stores a fraction of the absorbed ionizing radiation and releases this energy in the form of light photons when heated.

Total Effective Dose Equivalent (TEDE): means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Unrestricted area: means an area, where access to which is neither limited nor controlled by the licensee.

X-rays: is a penetrating type of photon radiation emitted from outside the nucleus of a target atom during bombardment of a metal with fast electrons.

This Manual was adapted from the Radiation Safety Manual prepared by the Center for Disease Control (CDC) in Atlanta available on the internet.

Forms



APPLICATION FOR THE USE OF RADIOACTIVE MATERIAL FOR BIOMEDICAL RESEARCH

Revised 11/29/2005

- | |
|---|
| <ol style="list-style-type: none">1. Submit original and two copies to the Radiation Safety Office.2. Each approved application is valid for one year.3. Please submit renewal 30 days before expiration date of current license. |
|---|

1. Name of Principal Investigator:

Please indicate:

New Application:

2. Department and Lab Number:

Renewal Application:

item # 16

If any changes please detail in

3. Telephone and extension number:

4. E-mail of Principal Investigator:

5. List training and previous experience of PI in the handling of radioactive material.

--

6. Title of research proposal

7. Funding Source(s)

--	--

8. List personnel to be handling radioactive material under PI's license and date of training

9. ☐ Undergraduate
☐ Graduate student
Student number

10. ☐ MSC Employee
Job title

--	--	--

11. Radioisotope(s) requested:

☐ ¹²⁵I

☐ ¹⁴C

☐ ³H

☐ ³²P

☐ ³⁵S

12. Name(s) of radioactive compound(s): (i.e. ¹²⁵I estradiol; ³⁵S enkephalin):

13. Provide the following information for each isotope requested

Isotope Activity (amount in mCi)	<input type="checkbox"/> ¹⁴ C	<input type="checkbox"/> ³ H	<input type="checkbox"/> ³² P	<input type="checkbox"/> ³⁵ S	<input type="checkbox"/> ¹²⁵ I
Amount requested per year					
Renewals: Current amount in freezer:					
Renewals: Current amount of waste					

14. Does the radioactive material present other potential hazards (i.e. Biological, Chemical?)

15. Name and address of commercial vendor:

16. For Renewal Applications. Please indicate if there has been any changes in the following areas:

Any changes in the following areas?	Yes	No	If yes, please detail
-------------------------------------	-----	----	-----------------------

Radioisotope:			
Protocol(s):			
Personnel:			

17. Description of experimental procedure with radioactive material:
May use additional pages.

18. Will the project involve administration of radioactive material?

To animals: ☐ Yes ☐ No

To humans: ☐ Yes ☐ No

19. Description of safety procedures while handling radioactive material:
May use additional pages.

20. Signature of Principal Investigator: _____ Date:

21. Signature of users: _____

FOR THE USE OF THE RADIATION SAFETY COMMITTEE

22. Signature of RSC President: _____ Approved Date:

23. Signature of RSO: _____ Approved Date:

24. Expiration date: _____

Note: The principal investigator must provide evidence of Radiation Safety Training for all personnel to be handling radioactive material. Remember, all personnel must take an annual refresher course. For further information please contact us at phone number (787) 758-2525 ext. 1647, 1648 or 1558.

INSTRUCTIONS ON COMPLETING APPLICATION FOR THE USE OF RADIOACTIVE MATERIAL FOR BIOMEDICAL RESEARCH

This form can be found at the following website (<http://committees.rcm.upr.edu>).

Eligibility: Only faculty members are allowed to apply for a radioisotope license. Students and laboratory technicians may use radioisotopes under the supervision of a licensed authorized user. By signing this application the authorized user is agreeing that byproduct material will be used only by, or under the direct supervision of, individuals who have at least 40 hours of training and have experience in the safe handling of radioactive materials.

New users: Please indicate if you are applying for the first time and provide a copy of your research proposal.

Renewals: If you are renewing your license, please indicate if there have been any changes and provide detail of changes on item 17. Submit application to the Radiation Safety Committee Administrative Assistant (Ms Teresa Soto: tsoto@rcm.upr.edu) 30 days before the expiration date of the current license.

- 1-4. Self explanatory
5. Provide a list of past training and experience, indicating date, place and type of isotope used.
- 6-7. Self explanatory
8. Provide a list and evidence of training, of all persons in your laboratory that will be handling radioactive material.
- 9 -10 Self explanatory. Please provide a copy of student ID or MSC employee's ID.
11. Indicate which isotope you requesting to use in your laboratory.
12. Indicate the chemical name of the compound (s) to be used (i.e. ^{125}I corticosterone, ^{32}P ATP)
13. Please indicate the amount of radioactive material (in millicuries, mCi) (1) stored and (2) in waste currently in your laboratory.

The broad scope license of UPR MSC granted by NRC states the maximum quantity (activity) of each isotope allowed on campus at any given time. This is divided among all investigators of the MSC. To calculate this amount one must add the amount in use, stored and in waste. We cannot exceed the allotted quantities that appear on our license. Consider your experimental protocol when selecting limits and take into consideration the activity of the commercially available material of interest. Requests for very large quantities of radioisotope should be fully justified on a continuation page.
14. Is radioactive gas generated? Is the material attached to chemical (toluene) or biological (viral) hazardous material?
15. Companies from which you usually purchase your radioactive material. New suppliers may request a copy of the MSC-NRC license. [Consult the RSO]
16. If you are renewing your application, provide a description of changes.
17. Provide a detailed description of the experimental protocol using the requested isotopes. You may cut and paste from your research proposal. You cannot write "see page ..." or cross reference to the Radiation Safety Manual or your research proposal.

18. The use of radioactive material in animals and/or human subjects for research purposes requires the approval of the pertinent IACUC or IRB committees.
19. Describe the procedures to ensure that all radioactive material will be received, handled, used, stored and disposed of in a safe manner that will ensure the well being of all radiation workers. Indicate clearly how the radioisotope will be used, what potential hazards (if any) are present in the experimental protocol, in which room and in which part of the room (table-top, hood, etc.) will the radioisotope be used. Describe the procedure used for receiving radioactive materials in your laboratory, the survey contamination methods used in your laboratory after each experiment, and the survey instruments used, the type of radioactive waste that will be generated and how will they be disposed of. Also describe your SOP in case of a spill or contamination of personnel, equipment, or an area. The RSO can provide additional details and assist you with this section.
20. Sign and date the application
21. All personnel to be handling radioactive material must read and sign the application.

MEMORANDUM

Date

Memo to: Chief of Security

From: Radiation Safety Officer

Subject: Receipt of Packages Containing Radioactive Material

The security guard on duty shall accept delivery of packages containing radioactive material that arrive during other than normal working hours. Packages should be placed on a cart or wheelchair and taken immediately to the storage area that is located in the Nuclear Medicine Department. Unlock the door, place the package on the floor, and relock the door.

If the package appears to be damaged, immediately contact one of the individuals identified below. Ask the carrier to remain at the facility until it can be determined that neither the driver nor the delivery vehicle is contaminated.

If you have any questions concerning this memorandum, please call our Radiation Safety Officer: _____ at _____.

Radiation Safety Office: _____ extension number _____

Chairperson of the RSC: _____ at _____

**University of Puerto Rico
Medical Science Campus
Receipt and Survey of Radioactive Material and Disposal of Packing Material**

IMPORTANT: IF THE PACKAGE WITH RADIOACTIVE MATERIAL IS DAMAGE/WET OR IF CONTAMINATION IS SUSPECTED, DO NOT MOVE OR OPEN THE PACKAGE, AVOID SPREADING THE CONTAMINATION. CALL THE RADIATION SAFETY OFFICE IMMEDIATELY. EXTENSION NUMBERS 1647, 1648 OR 1558.

Name of PI: _____ PO#: _____
 Name of person receiving isotope: _____
 Laboratory number: _____ Date received: _____
 Name of Isotope (Ex. ^{35}S): _____ Chemical Name: _____
 Amount of isotope (mCi): _____

Condition of Package: Damaged, Yes _____ No _____
 Is the package labeled as a W I, Y II, or Y III? Yes _____ No _____ Comparison of
 the packing slips and vial contents: Does not agree _____ Agrees _____

Instruments used for contamination surveys:

A. Swipe survey: For the following radioisotopes ^3H , ^{14}C , ^{32}P , ^{35}S and ^{125}I

_____ Liquid Scintillation Counter _____ Location 3rd Floor: Model LS 6500 Serial # 7069580
 _____ Liquid Scintillation Counter _____ Location 6th Floor: Model LS 6500 Serial # 7070616

Items	Trigger level < 200 dpm/100cm ² Beta or Gamma (dpm)
1. Blank or Control	
2. Box Exterior	
3. Box Interior	
4. Radioactive Plastic Container	
5. Radioactive Vial (stock solution)	

Contamination found No _____ Yes _____ If yes, state amount: _____ (dpm)

B. Geiger Muller (GM) survey: For the following radioisotopes ^{32}P , ^{35}S and ^{125}I

Scale of GM for survey: _____ mR/hr Series # _____ Model _____
 Probe: Series _____ Model _____

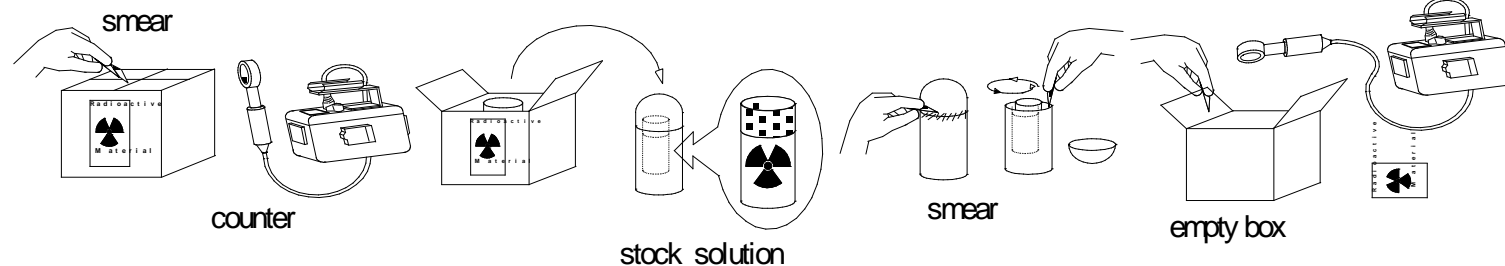
Items	Surface (mR/hr)	1 meter (mR/hr)
Background		
Box 1		
Box 2		

Contamination found No _____ Yes _____ If yes, state amount: _____ (mR/hr)

Please note: Before disposing of shipping container:

_____ Deface radioactive labels or wording, dispose of in regular trash.

_____ If shipping container is contaminated, dispose of as radioactive waste.



**MEDICAL SCIENCES CAMPUS
RESEARCH AREA**

ISOTOPE INVENTORY IN REFRIGERATOR OR FREEZER

PI: _____

Laboratory _____

Department _____

Date received	Isotope	Name of compound	Activity (mCi or μCi)	Lot #	Signature	Date removed

*This Inventory should be posted on the refrigerator or freezer.

UNIVERSITY OF PUERTO RICO

**MEDICAL SCIENCES CAMPUS
RADIATION SAFETY OFFICE**

**RADIOISOTOPE INVENTORY LOG SHEET
(Use a different sheet for each compound)**

PI: _____

Laboratory: _____

Isotope/Name of chemical (Ex. 35S-GTP): _____

Department: _____

Radioactive Material Received			Radioactive Material Used				Radioactive Material Disposed			
Date Received	Amount Received uCi / mCi	Initials	Date Removed	Amount Removed uCi / mCi	Amount Remaining uCi / mCi	Initials	Box/Gall on Label/ID	Solid Waste (uCi)	Liquid Waste (uCi)	Pickup date

UNIVERSITY OF PUERTO RICO

**MEDICAL SCIENCES CAMPUS
RESEARCH AREA**

RADIOACTIVE WASTE PICK UP SHEET

(Radioactive Waste from laboratories picked up by the Radiation Safety office, MSC, UPR)

PI: _____
Laboratory _____

Department _____

Date	Name (Isotope and Chemical)	Solid Waste (# of boxes)	Activity (μ Ci)	Liquid waste (In liters)	Activity (μ Ci)	Initials Laboratory Personnel	Initials Radiation Safety Office

RADIOACTIVE WASTE LABEL		
Name of PI:		Radioisotope:
Name of User:		
Laboratory #:	Telephone & ext.#:	
Date of last deposit:		Description: Liquid: () Vials () Solid: ()
Only for Radiation Safety Office:		Activity:

RADIOACTIVE WASTE LABEL		
Name of PI:		Radioisotope:
Name of User:		
Laboratory #:	Telephone & ext.#:	
Date of last deposit:		Description: Liquid: () Vials () Solid: ()
Only for Radiation Safety Office:		Activity:

DECOMMISSIONING RECORD

Permit No:	Isotopes Permitted				
Name:	Max. Quantity (mCi)				
Surveyor:	Date:				

AREA OR DEVICE

Building:	Room:	ID:
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SURVEY METER RESULTS

Instrument:	Calibration Date:	Background:
Surface Type	Measurement and Unit	Comments:

SWIPE TEST RESULTS

Instrument:	Calibration Date:	Avg. background:
Location	Results	Comments:
Map Attached: Y N	Swipe Report Attached: Y N	

According to the results indicated above, these areas are decommissioned and released for unrestricted use.

Radiation Safety Officer

Signature

Date