RADIATION SAFETY MANUAL

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I. INTRODUCTION

The Radiation Safety Manual is the official guide to the safe use of radioactive material at Florida Atlantic University (FAU). It is prepared by the Department of Environmental Health & Safety (EH&S) to present information and procedures, approved by the Radiation Safety Committee. These must be understood and practiced in order to ensure that all uses of radioactive materials are in compliance with applicable regulations and that any resultant exposures are "as low as is reasonably achievable," (ALARA).

II. RADIATION SAFETY PROGRAM

FAU, in fulfillment of its commitment to personnel safety and regulatory compliance, has established specific administrative entities with the responsibility of controlling the use of radioactive materials on all University campuses. EH&S has overall responsibility for developing and administering all safety and health programs at FAU, including the Radiation Safety Program. The Radiation Safety Program is managed by the Radiation Safety Officer (RSO) who is a member of the EH&S staff and serves on the Radiation Safety Committee.

III. RADIATION SAFETY COMMITTEE

The Radiation Safety Committee (RSC) was established by the Provost as the authority for establishing and administering policies and procedures for the safe use of radioactive materials and radiation emanating equipment as set forth in the Florida Department of Health, Bureau of Radiation Control (BRC) state regulations, Chapter 64E-5 of Florida Administrative Code (F.A.C.). The RSC consists of at least five (5) members, a Chairperson, the RSO, a representative of executive management, and other members that represent the various types of uses of radiation at FAU. In decisions, three members constitute a quorum. The RSC has final authority over all radiation usage at FAU.

The RSC is also responsible for reviewing and approving license amendment requests. In March 2004, FAU was issued a Broad Scope Radioactive Materials License (#734-4) by the BRC. This type of license places greater responsibility on the RSC and the RSO to independently manage FAU's Radiation Safety Program.

Specific duties of the RSC:

1. Meets at least once a quarter and at any other time at the request of a committee member or the RSO to resolve emergency matters relating to radiation safety.
2. Reviews all proposals for the use of radioactive material and radiation emanating equipment.
3. Terminates any operation which is judged to cause unnecessary exposure to radiation or which is likely to result in exposures exceeding the maximum permissible limits of the State of Florida.

4. Reviews the Radiation Safety Program for the following:
    - compliance surveys
    - procurement, storage, use, and disposal of radioactive materials
    - personnel dose records
    - training
5. Ensures that the use of radioactive material is consistent with the ALARA philosophy.
6. Assists the RSO to ensure compliance with applicable State regulations and license conditions.

IV. RADIATION SAFETY OFFICER

The Radiation Safety Officer (RSO) is responsible for the day-to-day administration and operation of the Radiation Safety Program at Florida Atlantic University. The RSO ensures that all activities involving radioactive materials, and/or ionizing and non-ionizing radiation emanating equipment, are performed in accordance with approved policies and regulatory requirements. The RSO is authorized to terminate or require immediate changes to an operation if, in the RSO's judgment, that operation is in violation of FAU policies and regulatory requirements.

The RSO must ensure that each individual using radioactive material is qualified by training and experience, has the facilities to handle the materials safely, and proposes a use that is safe to all concerned. The RSC and the RSO review all proposals for the use of radioactive materials. The RSO is also responsible for the following:

1. General surveillance of all activities involving radioactive materials and ensuring compliance with the regulations of the State of Florida and conditions of the license.
2. Personnel monitoring, maintaining exposure records, notifying individuals of exposures approaching the maximum permissible amounts, and recommending appropriate remedial action. Bioassays are performed when appropriate.
3. Monitoring of all incoming and outgoing radioactive materials for contamination and other hazard conditions or regulatory compliance.
4. Performing leak tests on all sealed sources as per license conditions.
5. Maintaining an inventory of all radioactive materials.
6. Performing surveys of all laboratories using radioactive material, maintaining records of the surveys and informing the PI and individual users if contamination is detected exceeding 200 disintegrations per minute (dpm).
7. Supervising decontamination in accidents involving radioactive materials.
8. Consulting with any personnel on all aspects of radiation safety and proper procedures for use of radioactive materials.
9. Providing initial, refresher, ancillary, and specific training as necessary.

V. AUTHORIZATION TO USE RADIOACTIVE MATERIAL

The individual in charge of a project using radioactive materials or radiation emanating equipment is referred to as the "Principal Investigator." Any FAU staff or faculty member who wishes to become a principal investigator (PI) must submit an *Application to Use Radioactive*

Material (RSO-1) form and a *Statement of Training and Experience* (RSO-2) form to the RSO. Personnel working under the supervision of a PI are designated as "Radiation Workers."

The PI is responsible for all activities under the scope of the authorization issued by the RSC. Basic safety duties may be assigned to experienced individual users but the primary responsibility rests with the PI who must be cognizant of the FAU guidelines for the use of radioactive material and must resolve any issues that may arise in the implementation of these guidelines. The PI must ensure that there are adequate resources (funds, personnel and space) to safely perform the research described in proposed radioactive material protocols. They are required to have training in the use of radioactive material although experience may be substituted for training at the discretion of the RSO and the RSC. The PI is also responsible for ensuring:

7. An up-to-date inventory of radioactive materials and radiation emanating devices are maintained and submitted to the RSO each quarter.
8. All uses of radioactive material or radiation emanating equipment must be evaluated (ALARA).
9. All individual users working on the project are properly authorized by the RSC, trained and supervised.
10. Compliance with all rules, regulations, and procedures for the purchase, use, storage, transfer, and shipment of radioactive materials or radiation emanating equipment.
11. All radioactive waste materials are properly prepared prior to collection by EH&S.
12. Periodic surveys of their laboratories are performed. Results of these surveys must be recorded and maintained for at least three years for inspection by the RSO.
13. The RSO is notified of any changes in the storage or use of any radioactive materials or radiation emanating equipment before such change is performed.

PERMIT AMENDMENTS

All changes to existing permits must be requested by submitting a letter outlining the changes to the RSO or completing a Request to Amend Radioactive Materials Authorization form (RSO-5). An amendment to the original PI's authorization is required for changes of radionuclide, possession limit, place of use, protocol, and addition or deletion of individual users.

PERMIT REVIEWS

The RSO reviews the use of radioactive material under an issued permit every two years. The PI should also periodically review the use of radioactive material in the lab and notify the RSO of any necessary changes to the permit.

PERMIT TERMINATION

The Principal Investigator should notify the RSO to terminate their permit if there will be an extended period of non use, such as a couple of years. A PI who remains in an active status but does not work with materials must continue to complete all radiation safety requirements including weekly documentation of "no use" in laboratory survey records, weekly surveys in areas where source and/or waste material are stored in the laboratory, quarterly inventory of radioactive material, and completion of training and annual refresher training courses.

LABORATORY TERMINATION

The Principal Investigator must notify the RSO at least thirty days in advance of any plan to permanently discontinue the use of radioactive material or the use of an approved laboratory. The RSO will arrange a final close out survey of the area being vacated. Prior to termination, the PI must:

1. Notify the RSO to remove all radioactive material (including waste) from the lab and update inventory records. Each stock vial must have a final disposal date.
2. Perform and document final monitoring and decontaminate if necessary.
3. Remove all radiation labels from within the lab. The RSO will remove the door label after a final close out survey has been completed.
4. Transfer all laboratory records to the RSO, especially if terminating employment at FAU.

VI. PROCUREMENT OR TRANSFER OF RADIOACTIVE MATERIAL

The acquisition of radioactive materials by purchase order, transfer, or gift requires prior approval from the RSO. All radioactive materials must be shipped to EH&S where they are monitored for contamination and entered into the inventory database before being delivered and signed for by the appropriate laboratory personnel. All shipments must be delivered to the following address:

Florida Atlantic University
Environmental Health and Safety
Campus Operations Building, #69, Room 112
777 Glades Road
Boca Raton, FL 33431
Attn: Radiation Safety Officer, RSS# (approval #)

PROCUREMENT

A Request for Radioactive Material (RSO-3) form must be submitted to the RSO. The RSO authorizes the procurement of the material after verifying that the PI is approved to receive the type of material ordered and that the requested amount does not exceed the possession limit. A radiation safety **approval number** (RSS#) is issued if the order is approved. Each stock vial, sealed source, standard, marker, etc. is also issued a 4 digit **inventory number** by the RSO. Each individual order will have a unique approval and inventory number assigned to it. For example, if an order of 2 x 0.250 mCi of P-32 is requested, each 0.250 mCi stock vial would require its own approval and inventory number.

TRANSFER OF RADIOACTIVE MATERIAL BETWEEN AUTHORIZED USERS

Radioactive material in the possession of a PI may be transferred after approval by the RSO. A Radioactive Materials Transfer form (RSO-4) must be completed and submitted to the RSO prior to transferring radioactive materials within FAU. All inventory records must be updated as necessary.

TRANSFER OF RADIOACTIVE MATERIAL FROM FAU TO OTHER RECIPIENTS

The transfer of radioactive material outside FAU requires prior approval from the RSO. The PI must complete and submit a RSO-4 form to the RSO. This form must include the amount and the name of the material, along with the name of the RSO at the receiving institution. Authorization for the transfer is granted after verification by the RSO that the intended receiver is authorized to possess the radioactive material that is being transferred by receiving the institution's NRC or Agreement State license prior to shipment. The material must also be packaged and shipped in accordance with regulatory requirements.

VII. TRAINING REQUIREMENTS

NEW EMPLOYEE TRAINING

Individuals who use radioactive material or frequent areas where radioactive material is used or stored must attend initial radiation training, which is only available in a classroom or laboratory setting. This training is offered monthly and on an as needed basis. All individuals wishing to attend radiation safety training should register to do so through EH&S.

ANNUAL REFRESHER TRAINING

Each calendar year, all persons who work in or frequent labs where radioactive material is used or stored must attend Annual Refresher Training. This training is available in a web-based format on the EH&S website.

VIII. POSTING AND LABELING

POSTING REQUIREMENTS

Each room approved for the use or storage of radioactive material must be posted at a minimum with a ***CAUTION RADIOACTIVE MATERIAL*** label and form DH-1081, *Notice to Employees*. These are both provided by EH&S.

LABELING REQUIREMENTS

1. **Work Stations**

   a. When possible, radioactive material use should be restricted to a specific, work area within the lab that is labeled with *CAUTION RADIOACTIVE MATERIALS.*

   b. Surfaces and pieces of equipment located within a labeled work area should be considered contaminated until an appropriate survey determines otherwise.

2. **Containers**

   Individual containers of radioactive material must be labeled with *CAUTION RADIOACTIVE MATERIALS.*

3. **Equipment**

Fume hoods, refrigerators, freezers, cabinets, centrifuges, pipettes, water baths, etc. used to store, process, or handle radioactive materials must be labeled as *Radioactive.*

IX. DOSE LIMITS

ALARA POLICY

The acronym **ALARA, "As Low As is Reasonably Achievable"**, means that persons using sources of ionizing radiation should make every reasonable effort to keep radiation exposures to individuals and releases of radioactive material to unrestricted areas as far below the regulatory limits as is practicable. The Administration of FAU fully supports the concept that all radiation doses should be ALARA. This implies that no dose is acceptable if it can be avoided or is without benefit.

Personnel shall constantly review their work habits and available safety equipment for adherence to the ALARA principle. The RSO will notify individuals when personnel exposures exceed ALARA levels. These exposures will be investigated and reviewed by the RSC. The RSO will investigate any individual's dose in excess of 125 mrem whole body or 1275 mrem to the extremities in any quarter.

ANNUAL OCCUPATIONAL DOSE FOR AN ADULT RADIATION WORKER

Whole Body (Head, Trunk, Upper Arms, and Thighs) *Total Effective Dose Equivalent*	5 rem (5000 mrem)
Lens of the eye *Eye Dose Equivalent*	15 rem (15000 mrem)
Skin or an Extremity *Shallow Dose Equivalent*	50 rem (50000 mrem)

ANNUAL OCCUPATIONAL DOSE FOR A MINOR

The annual dose limit for a minor working in a restricted area is 10% of the dose for an adult radiation worker. This is 0.5 rem or 500 mrem for a whole body dose.

ANNUAL DOSE FOR THE GENERAL PUBLIC

The annual dose limit for the general public is 0.1 rem or 100 mrem.

ANNUAL DOSE FOR AN EMBRYO/FETUS

The dose to an embryo/fetus, as a result of an occupational exposure of its mother, shall not exceed 0.5 rem (500 mrem) during the entire period of gestation.

ANNUAL OCCUPATIONAL DOSE FOR A DECLARED PREGNANT WORKER

A woman who works in an area that is restricted for purposes of controlling radiation exposure, may, upon learning that she is pregnant, declare her pregnancy in writing to the RSO. Once the pregnancy is declared in writing, which includes the estimated date of conception, the stated limits above become effective.

POLICY FOR PREGNANT WORKERS

A pregnant employee is highly encouraged to voluntarily inform her employer, in writing, of her pregnancy and the estimated date of conception. The employee is encouraged to visit the RSO and receive information regarding concerns she may have about radiation exposure during pregnancy. Upon submission of a completed *Declaration of Pregnancy* form, the RSO will:

1. Evaluate the exposure history of the individual and her coworkers.
2. Provide information concerning risk and precautions.
3. Evaluate the working environment with respect to radiation exposure.
4. Make recommendations for reducing radiation exposure.
5. Monitor radiation exposure in accordance with State of Florida exposure limits.

PERSONNEL DOSIMETRY

External exposure monitoring is required if an individual's occupational radiation exposure is likely to exceed 10% of the annual dose or 0.5 rem (500 mrem). Internal exposure monitoring is required if an individual is likely to receive in one year an intake in excess of 10% of the applicable Annual Limit of Intake (ALI) for ingestion and inhalation.

INTERNAL RADIATION DOSE LIMITS

To determine the total annual dose of an individual, the radiation dose from the inhalation or ingestion of radioactive materials must also be considered. The State of Florida places limits on the amount of radioactive materials that a radiation worker can take into their body over the course of a working year. This is called the Annual Limit on Intake (ALI). These values have been calculated for several radionuclides and are listed in Appendix B of this manual.

If a radiation worker receives one ALI, the calculated radiation dose from that intake would be 5 rem. This dose is called the Effective Dose Equivalent (EDE). Regulations require that the total external and internal radiation dose to a worker not exceed 5 rem in one year. The sum of these doses is called the Total Effective Dose Equivalent (TEDE).

THYROID BIOASSAYS

Radioiodine activities requiring bioassay are shown below:

Bioassay Levels for ^{125}I		
Type of Operation	**Volatile or Dispersible**	**Bound to Non-volatile Agent**
Processes in open room on bench top	1 mCi	10 mCi
Processes in a fume hood with adequate face velocity and performance reliability	10 mCi	100 mCi
Processes in a glove box or mini-hood with charcoal filter	100 mCi	1000 mCi

Thyroid scans are performed on individuals performing radioiodinations or using radioiodine compounds in excess of 10% of the limits in the table above. The scan is performed before initiating the radioiodination or radioiodine protocol and then between 7 hours and 168 hours afterward. All radioiodinations are performed in a charcoal filtered hood and are monitored by EH&S.

THYROID UPTAKE LIMITS

Weekly 600 nCi Investigation Level 120 nCi

TRITIUM BIOASSAYS

Individuals involved in operations that use tritium in any form other than metallic foil, in quantities greater than those listed in the table below will have bioassays performed. Tritium bioassays are performed by urine sample analysis. Any individual working with quantities greater than those shown in the table below 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 below shall provide urine samples weekly during the exposure and once after the exposure ends.

Bioassay Levels for Tritium				
Process	**Tritiated Water or Tritiated Compounds**	**Tritium Gas in Sealed Vessels**	**Tritium Nucleotide Precursors**	**Tritiated Water with more than 10 kg of Inert Water or Other Substances**
In open room with possible escape of tritium	0.01 Ci	100 Ci	0.01 Ci	0.01 Ci/Kg
Within fume hood of adequate design	1 Ci	1000 Ci	0.01 Ci	0.1 Ci/Kg
Within a glove box	10 Ci	10,000 Ci	1 Ci	1 Ci/Kg

Internal exposures will be added to the individual's external dose in accordance with 64E-5.305.

X. SURVEYS AND MONITORING

The laboratory must be surveyed for contamination **after each use** of radioactive material. At least one such survey must be **recorded WEEKLY.** Standard forms to document the monitoring results can be downloaded from the EH&S website.

If no radioactive material is used in a given week, an entry of "No RADIOACTIVE MATERIAL Use" must be recorded. However, if radioactive materials and/or waste are stored in the laboratory during weeks when radioactive materials are not used, a modified survey of the laboratory must still be performed each week. This survey can consist of the following: Wipes on each radioactive materials storage refrigerator or freezer, wipes of the floor beneath each refrigerator or freezer, and a wipe on the floor near each radioactive waste storage area. During weeks when radioactive material is used in limited areas within a laboratory, the survey may be limited to the applicable areas and "No RADIOACTIVE MATERIAL Use" recorded for other areas. If no radioactive material is to be used for extended periods of time, permit termination is recommended. What to monitor:

1. Include areas of potential radioactive contamination such as bench tops, the floor, telephones, doorknobs, faucet handles, freezer/refrigerator handles, etc. during routine monitoring.

2. Monitor all facilities and equipment (liquid scintillation counters, centrifuges, pipettes, refrigerators, fume hoods, RADIOACTIVE MATERIAL sinks, etc.) used with radioactive material prior to being returned for unrestricted use and before performing any maintenance or repair work.

HOW TO MONITOR

Survey meters should be used in areas where only gamma emitters (e.g. ^{125}I) or energetic beta emitters (eg.^{32}P) are used.

Use of survey meters:

1. Prior to use, check that the instrument is functioning by performing a battery test, checking the background reading, and assuring that it responds to radiation.
2. Verify that the meter and probe are appropriately sensitive for the radionuclide being monitored. Use a low-energy gamma scintillation probe for I-125; a pancake probe for energetic beta emitters like ^{32} P.

3. To perform a survey, move the meter/probe slowly (6 inches per second) over the surface to be monitored. Keep the face of the probe parallel to the surface, and as close as possible without contaminating the meter.

4. Do not use a meter in high background areas.

Performing a wipe test:

1. Put on gloves.
2. Drag the "wipe" over the surface to be tested applying moderate pressure and covering at least 100 cm^2.
3. Count the wipes in a liquid scintillation counter. Include one "blank" sample to verify that the background reading on the counter is consistent.
4. Dispose of wipes, vials, and gloves in accordance with EH&S waste disposal guidelines.

Records must include:

1. A diagram of the lab.
2. The date of the survey.
3. The initials/name of the person performing the survey.
4. The survey instrument used (not required for ^3H).
5. The background reading in counts per minute (dpm).
6. The survey results for each area in dpm.

Positive Monitoring Results

1. Results exceeding 200 dpm/100 cm2 must be decontaminated.
2. Following decontamination, resurvey the area. Record resurvey results in survey records.
3. For personnel contamination or widespread contamination, contact the RSO immediately.

INSTRUMENT CHARACTERISTICS

The following table lists the general types of radiation emitted by radionuclides approved for use at FAU. Typical detection efficiencies for commonly used survey probes are also listed.

Characteristic Radiation	Portable Survey Instrument	Laboratory Instrument
Low Energy Beta H^3, Ni^{63}	None Recommended	Liquid Scintillation Counter
Medium Energy Beta C^{14}, S^{35}, Ca^{45}	Ratemeter with end window or pancake GM detector	Liquid Scintillation Counter
High Energy Beta P^{32}	Ratemeter with end window or pancake GM detector	Liquid Scintillation Counter
Low Energy Gamma or X-ray I^{125}	Ratemeter with thin NaI(Tl) scintillation probe	Gamma Counter with semiconductor or scintillation detector Liquid Scintillation Counter.
Medium - High Energy Gamma Cr^{51}, Co^{60}	Ratemeter with thick NaI(Tl) scintillation probe or Energy Compensated GM	Gamma Counter with semiconductor or scintillation detector

TYPICAL DETECTOR EFFICIENCIES AND SENSITIVITIES FOR PORTABLE SURVEY METERS

Detector	Typical Efficiency	Detector	Sensitivity
End-Window GM	5% for C^{14} 5% for S^{35} 30% for P^{32}	Energy Compensated GM	1,200 CPM per mR/hr
Pancake GM	10% for C^{14} 10% for S^{35} 50% for P^{32}	Gamma Scintillator	175,000 CPM per mR/hr
Low-Energy Gamma Scintillator	35% for I^{125}		

LABORATORY COUNTERS

Liquid Scintillation Counters

Liquid scintillation counters should be calibrated annually using established standards of known activity. The counting efficiency for commonly used radionuclides should be known to calculate activity from counting data. The minimum detectable activity (MDA) of the counter for various radionuclides and counting times should also be calculated.

Scintillation counters often contain internal sealed sources. **Contact the RSO before moving or disposing of a counter, so arrangements can be made for proper removal and disposal of the internal radiation source.** Do not attempt to remove the source yourself.

Gamma Counters

Gamma counters should be calibrated annually using established standards of known activity. The counting efficiency for commonly used radionuclides should be known to calculate activity from counting data. The minimum detectable activity (MDA) of the counter for various radionuclides and counting times should also be calculated.

XI. RADIATION SAFETY AUDITS

The Radiation Safety staff performs audits on a quarterly basis to ensure that the use of radioactive material is being conducted in a safe manner and in accordance with regulatory requirements. These audits review the adequacy of facilities, training and competency of workers, availability of survey instruments, security of radioactive material, minimization of personnel exposure to radiation, and the required record keeping. All individuals working in the laboratory should be aware of the location of the radiation safety records and have them available for inspection by the radiation safety staff.

A written report of the audit is prepared by the RSO. The PI and individual users are informed of any deficiencies, violations or recommendations. The RSO issues a notice of violation if there is a violation of regulatory requirements or license conditions. The PI is required to respond to this notice of violation within thirty (30) days.

Audit reports are continuously reviewed by the RSO and the RSC for efficiency and effectiveness in ensuring a safe working environment. Audit results are reported to the Radiation Safety Committee quarterly.

XII. SECURITY

All radioactive material must be secured or under constant surveillance at all times. All radioactive material must be stored in a manner that prevents the possibility of unauthorized access or removal. For example, source vials of radioactive materials must be locked in a cabinet, refrigerator, or freezer and only the PI or individual users may have keys. The radioactive material could be placed in a locked box in a refrigerator or cold room, only if the box cannot be removed from the refrigerator or room. Radioactive waste containers must also be secured.

There currently is no lower limit on the amount of radioactive material that must be secured. Laboratory areas must be controlled or secured if ANY radioactive materials are present. It is recommended that all doors to the laboratory be locked when radioactive materials are either in use or in storage in the laboratory. Counting rooms must also be secured if radioactive materials are present.

REPORTING OF LOSS OR THEFT OF RADIOACTIVE MATERIALS

The PI or individual user will immediately contact the RSO in case of actual or suspected loss or theft of radioactive material. An investigation must begin immediately to attempt to locate the material. The RSO will notify the State of Florida as required.

XIII. GENERAL RADIATION SAFETY REQUIREMENTS

The safe use of radioactive material depends on all individuals being aware of the potential hazards and the proper procedures to control those hazards. Prior to using radioactive materials in a laboratory, the following steps should be taken:

- Become familiar with the radionuclide to be used, its characteristics, hazards, and appropriate handling techniques and storage requirements.
- Develop written procedures for all experiments, including safety precautions.
- Determine the need for any shielding or ventilation requirements.
- Designate a restricted area in which the experiment will be conducted.
- Clearly post the area and clear out unnecessary equipment.
- Perform a trial run of the experiment using non-radioactive materials to determine if the protocol is adequate.
- Analyze the waste stream to prevent the production of mixed chemical/radioactive waste.
- Maintain good housekeeping practices.

The following are the fundamental requirements for the safe use of radioactive materials in a research laboratory.

- Use the principles of time, distance, and shielding, and contamination control to keep exposure to radiation As Low As is Reasonably Achievable (ALARA).
- Eating, drinking, smoking, and applying cosmetics is prohibited in laboratory areas where radioactive materials are used or stored.
- Work areas (such as bench tops, hoods, and countertops) must be covered with absorbent matting or the work must be conducted within trays to contain spills.
- Plexiglas shielding is required when strong beta emitting radionuclides (^{32}P) are used.
- Lead bricks, foil, or lead impregnated plastic shielding may be required when gamma emitting radionuclides such as ^{125}I are used.
- Disposable gloves and laboratory coats should be worn when handling radioactive materials.

- Laboratories, rooms, animal facilities, or approved areas for use of radioactive materials must be posted with a *Caution Radioactive Materials* sign.
- Each container or piece of equipment in which radioactive materials are used and/or stored must be labeled in accordance with the applicable requirements of Florida Control of Radiation Hazard Regulations, Chapter 64E-5 of Florida Administrative Code (F.A.C.).
- Radioactive materials must be stored in labeled containers or storage areas and secured from unauthorized use or removal when not under surveillance by authorized individuals. This can be accomplished by ensuring that the laboratory room is locked when no individuals are present or by locking the refrigerator, freezer, or area at all times.
- Radioactive waste storage containers in the laboratory must be labeled with a "Caution Radioactive Materials" sign. Liquid waste should be placed in plastic containers (or plastic coated glass containers for organics) that prevent leakage or breakage and should be placed in secondary containers to contain spills. Containers with liquid waste must be sealed or capped to prevent the release of volatile byproducts.
- Laboratory glassware and other equipment used to work with radioactive materials must be labeled with a "Caution - Radioactive Materials" sticker and may not be removed from a laboratory or mixed with "clean" equipment until demonstrated to be free of contamination.

XIV. RADIOACTIVE EQUIPMENT RELEASE

Once used for radioactive substances, equipment shall not be used for other work, or sent from the area to central cleaning facilities, repair shops, surplus, or returned to the source of supply, until demonstrated and recorded to be free of contamination. The equipment must be surveyed and decontaminated by a laboratory employee who is familiar with the materials that were used or stored in the equipment. An equipment release form must be completed and submitted to EH&S. EH&S staff must be notified so a final survey of the equipment can be performed to verify the absence of radioactive contamination.

XV. RADIOACTIVE SEALED SOURCES

Sealed sources containing 100 µCi or more of beta-gamma radioactive materials are leak tested at six (6) months intervals. Sealed sources containing 10 µCi or more of alpha emitting radioactive materials are leak tested at intervals not to exceed three (3) months. Sources containing hydrogen-3 (^{3}H) are exempt from testing. The test must be performed in accordance with the manufacturer's instructions.

All storage, inventory, and use of all sealed sources are controlled. This includes small check sources and calibration standards that are exempt from leak testing. Sealed source inventory reports are to be submitted to the RSO semi-annually.

XVI. RADIOACTIVE WASTE PROCEDURES

WASTE PICKUP REQUESTS

Waste pickups are requested by generators either by telephone, on-line submission, or by faxing a “Request for Waste Pick-Up (RSO-9)” form to EH&S. Once notified EH&S personnel will respond in a timely manner, usually within two working days.

RADIOACTIVE WASTE GUIDELINES

When generating, handling, or storing radioactive waste the EH&S Radioactive Waste Guidelines must be followed. These are conspicuously posted by the temporary laboratory waste holding area and are also available on the EH&S website.

All Principal Investigators are required to submit specific protocols along with the expected waste streams to the RSO prior to generating any radioactive waste. The generation of mixed waste is strictly forbidden unless the RSO has given written permission. Laboratories are not allowed to dispose of any radioactive material either by drain or decay in storage. Waste must always be placed in an approved container with secondary containment which are both provided by EH&S. All containers must be labeled with a "Caution Radioactive Materials", a Radioactive Waste Log (RSO-11), and an EH&S waste tag.

XVII. RADIATION EMERGENCIES

EMERGENCY PROCEDURES

Emergency procedures should be readily available to all personnel working with radioactive material. The primary consideration should be given to protection of personnel and containment of the radioactivity. Campus Police should be contacted for emergencies that occur after normal business hours.

SPILL PROCEDURES (MINOR)

Spills or contamination involving < 100 uCi of non-volatile radioactive material are considered minor and may be cleaned up by lab personnel. However, at any time the RSO or radiation safety staff may be called for assistance.

- Report the spill to the RSO immediately if you need assistance, if there is personnel contamination, or if the contamination is outside the licensed area.
- Notify others in the area.
- Prevent the spread of contamination by covering the spill with absorbent material and limiting access.
- Clean up the spill using disposable gloves, lab coats, shoe covers and tongs (if appropriate).
- Proceed from the outermost edges of the contaminated area inwards, reducing systematically the area that is contaminated. Take care not to spread the contamination.
- Put all contaminated objects into radioactive waste receptacles.

- Normal cleaning agents are adequate. Keep cleaning supplies to the minimum needed to do the job.

- Place contaminated cleaning supplies into a plastic bag and labeled waste container.

- Following decontamination, survey all personnel and the area for removable contamination with a wipe test. If the floor was contaminated, be sure to monitor the bottom of shoes.

- Continue decontamination until wipe test results are less than 200 dpm/100cm2.

- Document results in laboratory notebook or records.

SPILL PROCEDURES (MAJOR)

Spills or contamination involving > 100 uCi of non-volatile radioactive material, any amount of volatile radioactive material, and/or personnel contamination are considered to be major. The RSO or radiation safety staff must be notified immediately and decontamination should not be attempted without the assistance of the RSO.

1. Evacuate the room immediately, shutting doors and windows on the way out.
2. Notify the laboratory supervisor.
3. Notify the RSO immediately by contacting EH&S at 297-3129.
4. Post *Keep Out* signs on all laboratory entrances to prevent access.
5. Assemble all persons near the lab entrance who were present in the laboratory during the spill.
6. Wait for assistance from the RSO before attempting to decontaminate the area.
7. Promptly report suspected inhalations, ingestions, or personnel contamination to the RSO.
8. Allow no one to return to work in the area unless approved by the RSO.

FIRES, EXPLOSIONS OR MAJOR EMERGENCIES

1. Notify all persons in the area to leave immediately.
2. Notify the fire department at # 911 and the RSO.
3. Attend to injured personnel first, then decontaminate.
4. Allow no one to return to work in the area unless approved by the RSO.

APPENDIX A

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) for Occupational Exposure

Nuclide	Oral Ingestion ALI uCi	Inhalation ALI uCi	Inhalation DAC uCi/ml
^{3}H	8×10^{4}	8×10^{4}	2×10^{-5}
^{14}C	2×10^{3}	2×10^{3}	1×10^{-6}
^{32}P	6×10^{2}	9×10^{2}	4×10^{-7}
^{33}P	6×10^{3}	8×10^{3}	4×10^{-6}
^{35}S	1×10^{4}	2×10^{4}	7×10^{-6}
^{45}Ca	2×10^{3}	8×10^{2}	4×10^{-7}
^{51}Cr	6×10^{3}	1×10^{4}	5×10^{6}
^{65}Zn	4×10^{2}	3×10^{2}	1×10^{-7}
^{125}I	40 1×10^{2} (thyroid)	60 2×10^{2} (thyroid)	3×10^{-8} ---
^{131}I	30 90 (thyroid)	50 2×10^{2} (thyroid)	2×10^{-8} ---

The above values are limits which would result in exposure of an annual committed effective dose equivalent of 5.0 rem to an adult individual or an annual committed dose equivalent of 50 rem to an individual organ or tissue.

APPENDIX B

COMMON RADIONUCLIDES AND THEIR CHARACTERISTICS

Calcium-45

Half-life: 163 days

Type of decay and Energy: Beta particle, 0.257 MeV (max)

Range in Air: 48 cm

Range in Water: 0.06 cm

Dose rate for typical quantities: No significant external exposure hazard.

Recommended Shielding: Plastic shield, any thickness, absorbs all beta particles.

Monitoring for contamination: GM detector, wipes counted by LSC.

Special Considerations: The low energy particles emitted from Ca-45 have a minimal penetration fraction for protective gloves or the outer layer of skin. Internal uptake is the primary concern since the critical organ is the bone. The annual limit on intake (ALI) is 2 mCi for oral ingestion or 800 μCi for inhalation.

Carbon-14

Half-life: 5730 years

Type of decay and Energy: Beta particle, 0.156 MeV (max)

Range in Air: 24 cm

Range in Water: 0.03 cm

Dose rate for typical quantities: No significant external exposure hazard.

Recommended Shielding: Plastic shield, any thickness, absorbs all beta particles.

Monitoring for contamination: GM detector, wipes counted in LSC.

Special Considerations: The low energy particles emitted from C-14 have a minimal penetration fraction for protective gloves or the outer layer of skin. Internal uptake is the primary concern since the critical organ is the bone for carbonates and body fat for many other compounds. The annual limit on intake (ALI) for compounds is 2 mCi for oral ingestion or for inhalation.

Cromium-51

Half-life: 27.7 days

Type of Decay: 0.32 MeV gamma (9.8%), 5 KeV X-ray (22%)

Dose rate for typical quantities: 160mR/hr at 1cm from 1mCi.

Recommended shielding: Lead shielding, 7mm thick.

Monitoring for contamination: Scintillation detector, wipes counted in LSC or gamma counter.

Special Considerations: Chromium-51 does not require any special precautions over and above those necessary for any radionuclide of these energies of emission. The GI tract is the critical organ for uptake. The annual limit on intake (ALI) is 40mCi for ingestion and 50mCi for inhalation.

Hydrogen-3

Half-life: 12.3 years

Type of decay and Energy: Beta particle, 0.019 MeV (max)

Range in Air: 0.6 cm

Range in Water: 0.0006 cm

Dose rate for typical quantities: No external exposure hazard.

Recommended Shielding: None required

Monitoring for contamination: Wipes counted in a LSC.

Special Considerations: The low energy particles emitted from H-3 cannot penetrate the outer dead layer of skin. Internal uptake is the primary concern since the critical organ is the whole body water. The annual limit on intake (ALI) is 80 mCi for oral ingestion or for inhalation.

Iodine-125

Half-life: 60 days

Type of decay and Energy: Gamma Rays, 35 KeV (7% of decays)

k-shell x-rays, 27-32 KeV (140% of decays)

Range in Air: 50 cm

Range in Water: 0.06 cm

Dose rate for typical quantities: 1.4 R per hour at 1 cm away from 1 mCi.

Recommended Shielding: Lead foil, 1mm thick, absorbs 99+% of photons.

Monitoring for contamination: Scintillation detector, wipes counted in LSC or gamma counter.

Special Considerations: Store NaI solutions at room temperature to minimize volatilization of compounds. Avoid acidic solutions. The thyroid is the critical organ for uptake. The annual limit on intake (ALI) for the thyroid is 40 µCI for oral ingestion or 60 µCi for inhalation.

Phosphorus-32

Half-life: 14.3 days

Type of decay and Energy: Beta particle, 1.709 MeV (max)

Range in Air: 790 cm

Range in Water: 0.8 cm

Dose rate for typical quantities: 26 rem per hour at the mouth of an open 1 mCi vial in 1 ml of liquid.

Recommended Shielding: Plastic shield 1cm thick absorbs all beta particles.

Monitoring for contamination: GM detector, wipes counted in LSC.

Special Considerations: Do not use lead shielding for high energy particles. This produces x-rays that are harder to shield. The bone is the critical organ for uptake. The annual limit on intake (ALI) is 600 µCI for oral ingestion or 900 µCi for inhalation.

Phosphorus-33

Half-life: 25.4 days

Type of decay and Energy: Beta particle, 0.249 MeV (max)

Range in Air: 49 cm

Range in Water: 0.06 cm

Dose rate for typical quantities: No significant external exposure hazard.

Recommended Shielding: Plastic shield, any thickness, absorbs all particles.

Monitoring for contamination: GM detector, wipes counted in LSC.

Special Considerations: The bone is the critical organ for uptake. The annual limit on intake (ALI) is 6 mCi for oral ingestion or 8 mCi for inhalation.

Sulfur-35

Half-life: 87.4 days

Type of decay and Energy: Beta particle, 0.167 MeV (max)

Range in Air: 28 cm

Range in Water: 0.03 cm

Dose rate for typical quantities: No significant external exposure hazard.

Recommended Shielding: Plastic shield, any thickness, absorbs all beta particles.

Monitoring for contamination: GM detector, wipes counted in LSC

Special Considerations: S-35 amino acids can decompose to volatile compounds during storage. Always open stock vials in an operating chemical fume hood. Incubation of S-35 methionine may release volatile compounds. The incubator may become contaminated.

The low energy particles emitted from S-35 have a minimal penetration fraction for protective gloves or the outer layer of skin. Internal uptake is the primary concern since the critical organ is the whole body. The annual limit on intake (ALI) for most compounds is 10 mCi for oral ingestion or 20 mCi for inhalation.

APPENDIX C

Application to Use Radioactive Material

Date:	Duration of Study:
Authorized User:	Department:
Telephone:	Bldg/Office No:
Email address:	Fax:

1. A protocol must be included that provides a general description of the research plan including how the radioactive material will be used and any significant handling or storage hazards. Describe any personal protective clothing that will be worn, shielding that will be used, and whether work will be performed in a hood.

2. List each isotope, form, compound and the amount of activity that will be used in this study.

Radionuclide	**Physical Form** (solid/liquid/gas)	**Chemical Compounds**	**Maximum Quantity per experiment** (mCi)	**Maximum Quantity to be Possessed** (mCi)

3. Use and Storage Locations

Please provide building and room numbers where radioactive will be used and/or stored and attach a diagram of each location. (Indicate the location of hoods, benches, refrigerators/freezers, doors and intended use and storage areas.)

Bldg/Room #	**Room type (Use, Storage, Counting, etc.)**

4. **Radiation Detection Equipment**

List the types of radiation detection instruments that will be used to monitor radiation levels and perform contamination surveys.

Equipment Type	Manufacturer	Model	Serial Number

5. **Associate Users**

Attach Statements of Training and Experience (RSO-2) forms for all individuals that will work under the supervision of the Principal Investigator.

6. **Program Requirements**

All requests for radioactive material will be submitted to the Radiation Safety Officer for approval.

Records will be maintained for the receipt, use and disposal of all radioactive materials.

A survey with a radiation survey instrument shall be completed at the end of each day of use of all areas where radioactive materials are used or received. A weekly survey with a radiation survey instrument will be performed of all areas where radioactive materials or radioactive waste are stored.

A wipe survey shall be completed for removable contamination weekly during weeks of use of all areas where radioactive materials or radioactive waste are routinely used or stored. A wipe survey is required for removable contamination at the end of each day of use of all areas where radioactive materials are routinely used, if the radioactive materials are not detectable with portable survey instruments (i.e. ^{3}H)

Radioactive materials will be secured against unauthorized removal when the materials are not under the direct surveillance of an authorized user.

Waste disposal procedures will comply with FAU policies and State of Florida regulations.

I have read and will abide by the University program requirements and policies set forth in the FAU Radiation Safety Manual.

Signature:	**Date:**

Statement of Training and Experience

(*To be completed by ALL personnel who will be working with radioactive materials*)

Name:	Department:	Ext.:
Classification: (*Faculty, Technician, Student, etc*.)	Radioactive Material to be used:	Principal Investigator:

Type of Training	Where Trained	Dates and Duration of Training	On the Job?	Formal Course?
A. Principals and practices of radiation protection			Yes☐ No☐	Yes☐ No☐
B. Radioactivity measurement, standardization, monitoring techniques and instruments			Yes☐ No☐	Yes☐ No☐
C. Mathematics and calculations basic to use and measurement of radioactivity			Yes☐ No☐	Yes☐ No☐
D. Biological effects of radiation			Yes☐ No☐	Yes☐ No☐

Radioisotope Handling Experience

Isotope	Maximum Amount	Where Experience was Gained	Dates and Duration of Experience	Types of Use

Have radiation exposure records been maintained for you at another institution? ☐YES ☐ NO

I have read and will abide by the University regulations set forth in the FAU Radiation Safety Manual.

Signature	*Date*

If additional space is needed, use the back of this sheet or attach additional sheets.

REQUEST FOR RADIOACTIVE MATERIAL

(Please Attach a Separate Copy of this Form for Each Isotope Requested)

Principal Investigator/User:			**Date:**	**Date Requested By:**
Bldg:	**Room #:**	**Email:**	**Phone:**	**Fax:**
Radionuclide:		**Chemical Compound:**		**Activity:**
Physical Form:		**Supplier:**	**Catalog #:**	**P.O.#:**
RSS#:		**Date:**	**Approved By:**	
RECEIPT				
Transportation Label: ☐ **None** ☐ **White** ☐ **Yellow-II**		**Trans. Index:**	**Condition:** ☐**OK** ☐**Damaged/Wet**	
Radiation Level:			**Wipe Test Result:**	
Survey Meter Model:		**Serial #**	**Counter:**	
Inventory#:		**Reference Date:**	**Lot #:**	
Survey performed by:			**Date surveyed:**	
Delivered to:			**Date:**	

USE LOG/DISPOSAL

Date	Amount used	Amount Remaining	Amount to Waste	Initials

When amount remaining in source vial is 0, place vial in bag, attach completed RSO-3 and call EHS for disposal at (561)297-3129.

Transfer of Radioactive Material

☐ Within FAU:

☐ Outside FAU*

From:

Principal Investigator:	Department:	Date:

To:

Name:	Department:
Address:	City:
State:	Zip:
Telephone No.	License No:

Isotope:	Activity: (uCi/mCi)	Compound:	Form: (solid/liquid/gas)

Shipping Instructions :(***circle one***)

As is	Keep Frozen	Refrigerate	Prevent Freezing
Ship Date:	Carrier:	Packing Method:	
Remarks:			

**Radioactive materials shall not be transferred to or from a FAU facility or outside organization without prior approval from the Radiation Safety Officer. A copy of the NRC/Agreement State License must be received by the RSO prior to the transfer of radioactive material to an outside organization.*

Amendment to Radioactive Materials Authorization

Date:	Department:
Principle Investigator:	Bldg/Office No:
Telephone:	Fax:
Email address:	

1. Add or remove radioisotopes

If you are requesting the addition of a new radioisotope(s) to your authorization, use or quantities, a specific protocol must be included that provides a general description of the research plan including how the radioactive material will be used and any significant handling or storage hazards. Describe any personal protective clothing that will be worn, shielding that will be used, and whether work will be performed in a hood.

Radionuclide	**Add or Remove**	**Physical Form** (solid/liquid/gas)	**Chemical Compounds**	**Maximum Quantity per experiment** (mCi)	**Maximum Quantity to be Possessed** (mCi)

2. Add or remove use and storage locations

Please provide building and room numbers for additional laboratories where radioactive will be used and/or stored and attach a diagram of each location. (Indicate the location of hoods, benches, refrigerators/freezers, doors and intended use and storage areas.)

Bldg/Room #	**Add or Remove**	**Room type (Use, Storage, Counting, etc.)**

3. Add or remove radiation workers

Attach Statements of Training and Experience (RSO-2) forms for all individuals that will work under the supervision of the Principal Investigator.

Name	Add or Remove	Isotopes to be used

4. Add or remove radiation detection equipment

List the types of radiation detection instruments that will be used to monitor radiation levels and perform contamination surveys.

Equipment Type	Manufacturer	Model	Serial Number	Add or remove

5. Principle Investigator Leave of Absences/Sabbaticals

List the dates of leave along with the names of all radiation workers who plan to work with radioactive materials during the time of leave. All radiation workers wishing to continue their work with radioactive materials during the Principle Investigator's absence must do so under the authorization of another Principle Investigator. The Principle Investigator assuming responsibility of the radiation workers must sign in the space indicated below.

Dates of Leave	Radiation Workers to be transferred	Principle Investigator assuming responsibility	Signature	Date

All amendment requests must be submitted to the RSO for review and approval. If approved by the RSO, the amendment will be submitted to the State for final approval. This process usually takes between four and six weeks to complete. You will be notified once your amendment has been changed on the FAU Radioactive Materials License.

Signature:	**Date:**

Sealed Source Inventory
(Semi-annual)

Authorized User:	Date Inventory was performed:
Department:	Phone:
Bldg/Room #:	Email:

Please list each sealed source in your possession.

Manufacturer	Model	Serial #	Isotope	Activity (mCi)	Location (Bldg/room)	Date Received

Authorized User

Signature:	Date:

Radiation Safety Officer

Signature:	Date:

Area Survey Report

Principle Investigator:	Date:
Department:	Building/Room:

Room Diagram—Available from EH&S

Wipe #	Wipe Result in DPM	Meter Survey results (CPM or mR/hr)
1*		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

***Attach printout of wipe result data**

Survey Meter Model:	**Calibration Date:**
Meter serial #:	**Background (CPM or mR/hr):**
Surveyed By:	**Date of Survey:**

NOTE: On average, 10-15 wipes are sufficient for most labs, however some may require more or less depending on size, radiation use equipment, waste storage areas, etc.

Exposure History Request Form

TO: **Radiation Safety Officer**

Institution:		
Street Address:		
City:	State:	Zip:
Department:		
Dates of Employment:		

I am currently working at Florida Atlantic University and will be handling radioisotopes. I request that you send a copy of my Occupational Radiation Exposure History be sent to the Radiation Safety Officer at FAU so that he/she may have my complete radiation history, as required by the State of Florida and the U.S. Nuclear Regulatory Commission regulations. I have listed my name, social security number, department and dates of employment at your institution to expedite the location of my radiation history.

Thank you for your prompt attention to this matter.

Name:	Signature:	
Birth date:	Social Security No:	
Street Address:		
City:	State:	Zip:

Please return this form to:

Radiation Safety Officer
Environmental Health & Safety Office
Florida Atlantic University
Campus Operations Bldg #69, Rm.112
777 Glades Road
Boca Raton, FL 33431
Phone: (561) 297-1052 Fax :(561) 297-2210

Florida Atlantic University
Environmental Health & Safety **RSO-9**

Request for Radioactive Waste Pick-Up

Authorized User:	Bldg/Room:	Date:

Isotope:	Solution/Composition:	Activity: (uCi/mCi)	☐ Liquid ☐ Solid ☐ LSV	Volume/Weight:	Container Type
Isotope:	Solution/Composition:	Activity: (uCi/mCi)	☐ Liquid ☐ Solid ☐ LSV	Volume/Weight	Container Type
Isotope:	Solution/Composition:	Activity: (uCi/mCi)	☐ Liquid ☐ Solid ☐ LSV	Volume/Weight	Container Type
Isotope:	Solution/Composition:	Activity: (uCi/mCi)	☐ Liquid ☐ Solid ☐ LSV	Volume/Weight	Container Type
Isotope:	Solution/Composition:	Activity: (uCi/mCi)	☐ Liquid ☐ Solid ☐ LSV	Volume/Weight	Container Type
Isotope:	Solution/Composition:	Activity: (uCi/mCi)	☐ Liquid ☐ Solid ☐ LSV	Volume/Weight	Container Type
Isotope:	Solution/Composition:	Activity: (uCi/mCi)	☐ Liquid ☐ Solid ☐ LSV	Volume/Weight	Container Type

Special Handling Precautions:

NOTE: If the isotope is in solution, please indicate the solvent and solute components and concentrations. Also, please avoid generating "mixed waste" (radioactivity in EPA regulated hazardous waste) since it is difficult to comply within the time frame for its disposal as required by Federal and State regulations.

Request for Dosimetry

NAME:	**Authorized User:**	
Division:	**Bldg:**	**Room:**
Phone:	**Email:**	
Social Security No:	**Date of Birth:**	**Male** ☐ **Female** ☐
Radionuclides to be used:		
Circle the type of badge you need:		
Whole Body		
RING INDICATE SIZE: S M L		
Fetal Monitor		
Area Monitor ☐ **Number requested:**		

Signature:	**Date:**

Radioactive Waste Disposal Log

Date	Isotope	Activity (uCi)	Initials

Declaration of Pregnancy

I, _____ , hereby am declaring I am pregnant. I believe
(print name)

I became pregnant in _____.
(month, year)

I understand that my occupational radiation dose during my entire pregnancy will not be allowed to exceed 0.5 rem (500 mrem), unless that dose has already been exceeded between the time of conception and submitting this letter. I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

If I find out that I am not pregnant, or if my pregnancy is terminated, I will promptly inform you that my pregnancy has ended.

Signature:	**Date:**
RSO Review:	**Date:**