

Rutgers Environmental Health and Safety

RADIATION SAFETY GUIDE

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RADIATION SAFETY GUIDE

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I. INTRODUCTION AND ALARA POLICY STATEMENT

A. Introduction

The use of radioactive materials and machine sources of ionizing radiation are regulated by the United States Nuclear Regulatory Commission (NRC) or the New Jersey Department of Environmental Protection, Bureau of Radiological Health (NJDEP). Rutgers University has received licenses of broad scope from both of these agencies permitting considerable autonomy in the use of sources of ionizing radiation and the management of our radiation safety program. For the purposes of this guide, “radiation” may be used interchangeably with “ionizing radiation”.

Non-ionizing radiation-producing equipment is not currently subject to a government-licensing program, however there are federal and/or State standards and exposure limits as well as professionally accepted practices pertaining to sources of non-ionizing radiation. Should you have questions or concerns regarding non-ionizing radiation, please contact Rutgers Environmental Health & Safety (REHS).

This Guide (1) describes the organization of the radiation safety program and the responsibilities of all levels of employees pertaining to the radiation safety program; (2) specifies the regulations, policies and practices that must be followed when using sources of radiation; (3) describes the radiation services that REHS provides to assist the user in his/her safety program; and (4) describes the basics of radiation physics and biological effects.

Rutgers University has appointed a Radiation Safety Committee to establish a comprehensive radiation safety program to ensure that all sources of radiation are used in a safe and compliant manner. In every facility where radioactive materials are utilized, specific methods must be developed to maintain safety and compliance.

Work with sources of ionizing radiation may not be initiated until written authorization has been received specifically permitting that work and all training requirements have been met.

B. ALARA Policy Statement

In practice, radiation doses in the workplace must be maintained **As Low As Reasonably Achievable**. ALARA is a guideline meant to strike a balance between the costs of radiation protection, the health benefit derived from that protection and the benefit to society as a result of the use of ionizing radiation. The limits for occupational exposure are clearly written into the regulations and constitute the industry’s “standard of care”. That said, our ALARA program is important and acts as a best management practice. The University’s administration and the radiation safety staff will promote ALARA and assist the research and administrative community in practicing ALARA at every available opportunity.

It is the responsibility of all parties including radiation workers, authorees, REHS and the University administration to maintain operations with ALARA in mind. This is achievable, in part, by outlining safety procedures for work involving radioactive materials and diligently monitoring the workplace to control the spread of contamination. Practical measures to incorporate ALARA into work practices are included in this manual to assist radiation workers. Simple concepts and easily implemented best practices will generally minimize contamination, exposures and releases.

II. PROGRAM MANAGEMENT

A. Radiation Safety Committee

The Radiation Safety Committee (RSC) along with University Administration and the Radiation Safety Officer (RSO) share responsibility for the University's radiation safety program. The RSC is critical for licenses of broad scope such as Rutgers and allows the University relative autonomy in making decisions regarding the radiation safety program and its management. In line with the high level of standards and integrity set by our administration, a proactive, involved and informed RSC is essential.

The RSC is formally appointed by the University Administration, typically, the Vice President for Academic Affairs. RSC membership is comprised of a member of the Administration, the RSO and faculty representing the major areas of radionuclide use and radiation producing machines. Whenever practical the various campuses and geographical areas of the University are represented.

A quorum of the RSC members must be present in order for the RSC to officially transact business. A quorum consists of:

1. The Chair (or his/her designee)
2. The Representative of Administration (or his/her designee)
3. The Radiation Safety Officer
4. At least two other faculty members

The RSC is charged with the following duties:

1. Review and approve the policies for the radiation safety program, including the Radiation Safety Guide to:
 - Promote the practice of the ALARA philosophy for all members of the University community and the general public;
 - Insure compliance with all applicable regulations;
 - Promote the sound and environmentally responsible disposal of waste materials.
2. Approve in advance all authorized uses of licensed materials. This includes new procedures under the RSO's authorization.
3. Audit and/or approve the audit of the radiation safety program and the radiation safety office on an annual basis. This audit shall be thorough and include, but may not be limited to: the policies and procedures for controlling and maintaining inventories, possession limits, the procurement and transfer of licensed materials, emergency response, training of users, security, and dosimetry.
4. Approve revisions to the Radiation Safety Guide, as well as other documents and procedures without prior notification to the Nuclear Regulatory Commission (NRC) as long as these changes are not in conflict with specific license conditions or specific NRC regulatory requirements.
5. Adjudicate any differences between authorized users and REHS.

The RSC typically meets at least four times per year. Students, faculty, staff and members of the general public are encouraged to contact any member of the Committee to discuss issues of concern regarding any aspect of our radiation safety program. A listing of the current RSC members is available on the REHS website or may be obtained by contacting REHS directly.

B. Radiation Safety Officer Responsibilities

The responsibilities of the RSO and University Health Physicist (UHP) are as follows:

1. Provide consultation to authorized users on good radiation safety practices, experimental design, adequate facilities, selection of monitoring equipment, etc.
2. Oversee the receipt, delivery and shipment of radioactive materials.
3. Establish criteria for compliance with state, federal and local regulations, license conditions and the permit conditions authorized by the Radiation Safety Committee.
4. Inspect authorized users and their labs to insure compliance with the criteria defined above.
5. Immediately terminate any activity that is found to be a threat to public health and safety, property or the environment.
6. Provide radiation protection information to personnel pursuant to 10 CFR 19.12 and 10 CFR 20.
7. Periodically meet with and report to University Administration and the Radiation Safety Committee.

The University Community is encouraged to contact REHS with any questions or concerns regarding the use of ionizing radiation. Email addresses of the radiation safety staff are available on the website.

C. REHS Services

The following is a list of common services provided by REHS.

1. Laboratory Inspections
REHS staff will inspect labs on a quarterly basis. During these inspections REHS will perform the following at a minimum:
 - Check daily surveys and monthly contamination wipes
 - Ensure waste is properly segregated and labeled
 - Survey the lab for contamination
 - Ensure the lab is properly posted
 - Provide assistance/advice for radiation related issues
2. Radiation and Contamination Control
During inspections, REHS will conduct surveys with a portable instrument (if applicable), and may perform wipe tests of the lab on an annual basis. Radiation producing machines are surveyed:
 - Upon installation
 - After being relocated or moved
 - After a repair or modification
 - Annually or semi-annually depending on the unit classification

3. Radioactive Waste Disposal and Pick-up

All radioactive wastes must be disposed through REHS.
Drain disposal of radioactive wastes is prohibited.

Radioactive wastes are segregated by waste type (solid, liquid, scintillation vials, animal etc) and then by half-life. All radioactive wastes shall be segregated in accordance with University guidelines outlined in Waste Disposal Procedures; Section XI of this guide.
4. Personal Radiation Monitoring

Staff working with sources of radiation may be required to wear personnel monitoring badges. Authorees shall ensure that all badges assigned to their laboratory are used properly and returned to REHS on time. REHS maintains all radiation exposure records and can provide an individual's report upon request. Individuals who do not require personnel monitoring as stated in Section VII (A) of this guide may request a badge, but may be required to pay for the cost of the badge.
5. Bioassays

REHS provides bioassay services as needed. Staff performing iodination procedures with I-125 must obtain a thyroid bioassay 24 to 72 hours post iodination. Bioassay requirements associated with other uses of radionuclides or in the event of personal contamination are determined by REHS on a case-by-case basis.
6. Instrument Checks

All portable survey instruments are checked for proper operation by REHS on an annual basis. REHS can assist with repairs and coordinate with vendors to arrange repair service.
7. Radiation Safety Training

All authorees and radiation workers are required to attend:

 - Initial Radiation Safety Training prior to beginning work with radioactive materials
 - Refresher training annually following Initial. Refresher is offered in-person approximately two times per month at various locations around the University. Refresher is also offered in an online format through the REHS web page.
8. Emergency response

REHS provides emergency response to incidents involving radioactive materials. Contact REHS directly during normal working hours and Campus Police at all other times.

D. Enforcement Policy

1. Introduction

A well-functioning radiation safety program is dependent on consistent adherence to the policies and procedures established for the safe use of radioactive materials. The NRC has two basic assumptions regarding safety: (1) consistently following the requirements leads to safety and (2) the only way to ensure consistent compliance and therefore, safety is through comprehensive management controls.

The NRC expects the University to have a rigorous program of laboratory safety audits. It is important to realize that the NRC holds the institution responsible for the actions of the individuals working here. With this in mind, REHS inspects each authorized laboratory at least quarterly. These inspections are unannounced and generally very thorough. The results of these audits are discussed with the individual(s) present in the lab at the time of the inspection and a written report is forwarded to the authoree.

The self-identification and correction of violations by the University are well regarded by the NRC. Conversely, the failure to identify violations or the failure to correct those identified can lead to enforcement action by the NRC. Whenever possible, REHS works pro-actively with the laboratory community to correct violations and ensure they do not recur. In the event that violations are not corrected or are of sufficient severity, a Notice of Violation (NOV) may be issued to the Authoree.

NOVs are classified as MAJOR or MINOR. Major violations have the potential to cause risk to human health or welfare, the health or welfare of the environment or may jeopardize the institution's license status with the NRC or the State.

The following is a list of examples of MAJOR violations:

- Failure to perform and/or document monthly wipe tests or daily surveys
- Failure to use the proper personal protective equipment
- Failure of the Authoree to meet the refresher training requirements
- Allowing new employees to work with licensed material without proper training
- Significant, undetected contamination in the laboratory
- Eating, drinking or smoking in the lab (or evidence thereof)
- Failure to notify REHS or campus police in a timely manner after a major incident
- Disposal of radioactive materials in the regular trash and/or loss of licensed material
- Failure to secure licensed source material (i.e. a source vial)

The following is a list of examples of MINOR violations:

- Failure to secure other licensed material
- Lack of secondary containment for liquid wastes
- Failure to properly segregate radioactive wastes
- Failure to maintain an accurate inventory of radioactive materials
- Failure to perform the efficiency, MDA or CPM to DPM calculations on wipe tests
- Failure of radiation workers to meet refresher training requirements
- Failure to maintain a functional survey meter

2. Authoree Response to NOV

Authorees must provide a written response to the RSO or UHP acknowledging the NOV and detailing corrective actions that will be taken to prevent recurrence. The Authoree may choose to contest the NOV if he/she feels it was issued without sufficient cause. If the Authoree chooses to contest the NOV, a written response shall be provided to the UHP detailing why he/she believes the NOV should be rescinded. If the UHP and the Authoree cannot agree on the disposition of the NOV, the matter will be referred to the Committee for adjudication.

3. Potential Sanctions

The RSO is responsible for the safe use of ionizing radiation at the University. The RSO may immediately suspend the permit of an Authoree at his/her discretion. The suspension will remain in force until an emergency meeting of the Committee can be convened to resolve the issue.

The RSO and RSC typically take a graded approach to enforcement. If an Authoree receives two NOVs within four inspection cycles (one year) he/she may be asked to meet with representatives of the RSC to discuss the preventative measures that need to be taken by the laboratory. Factors such as the seriousness of each NOV and the effectiveness of past and proposed corrective measures will factor into whether or not a meeting is requested and whether or not enforcement sanctions are warranted.

If an Authoree receives three major NOVs within four inspection cycles, there will be a mandatory meeting with representatives of the RSC. In this event, it is likely that sanctions will be imposed on the Authoree's permit.

The Committee is responsible to insure the University's ability to use licensed material is protected. The Committee will discipline an Authoree in an effective and appropriate manner and enforce sanctions on individual labs that are recurrent offenders with this goal in mind. Options for sanctions include, but are not limited to:

- Required in-service training by REHS
- Probationary status - may use licensed material, but inspection frequency will be doubled for term of probation and suspension will be likely should a NOV be issued during probationary term
- Suspension of use of licensed material (typically between 2 weeks and 6 months)
- Permanent revocation of permit

III. AUTHORIZATION TO USE RADIOACTIVE MATERIALS

A. Minimum Requirements, Application and Approval

The use of radioactive materials at the University is restricted to personnel authorized by the Committee. Faculty and staff meeting the minimum criteria outlined below shall complete and submit an application package to the RSO or University Health Physicist (UHP).

Minimum criteria:

1. Hold a faculty or staff position with at least the rank of Instructor, Research Associate, or its equivalent.
2. Possess a graduate degree in a Physical Science, Life Science, Engineering, or Medicine; and have at least one year of experience working with radionuclides of similar characteristics and activity. Required experience for radiation producing machine authorizations will be handled on a case-by-case basis by the RSC.
3. Have the use of adequate facilities and equipment to contain and detect the radionuclides requested. This may include but is not limited to, a laboratory with impervious floor and bench surfaces, a chemical fume hood for volatile materials, appropriate shielding and portable survey instruments capable of detecting the requested radionuclides, and access to a liquid scintillation counter for conducting wipe tests.
4. Must have attended Initial Radiation Safety Training

The RSO/UHP will review the application, conduct an interview and submit their findings to the RSC for consideration. If authorization to use is granted, a Radioactive Material Permit will be issued by the RSO/UHP on behalf of the RSC and will be valid for a period of two years. The permit specifies the name of the Authoree, the room(s) in which radioactive materials may be used, the nuclide(s) to be used, and the maximum quantity of each nuclide permitted.

The "Application to Use Radioactive Materials" can be found in the Appendices and on the REHS web page.

B. Authoree Responsibilities

The Authoree is responsible for the safe use of all radioactive materials obtained under their permit and for ensuring that all radiation workers under their permit are working in accordance with applicable regulations and University policies at all times.

The Authoree shall:

1. Attend radiation safety training at the required frequency
2. Ensure that all radiation workers attend radiation safety training at the required frequency
3. Ensure that all radiation workers receive in-lab training specific to the procedures and experiments authorized in the permit
4. Ensure that radioactive materials are used only in approved locations listed on the permit
5. Inform all non-radiation workers of the potential health hazards and the safeguards that are established to ensure a safe workplace
6. Administer and enforce the radiation safety rules and regulations as outlined in this guide and other University policies
7. Notify the RSO/UHP of any prolonged absences or sabbaticals (in excess of four consecutive weeks) so an alternate Authoree may be identified
8. Ensure laboratory surveys for radioactive contamination are performed and documented at the appropriate frequency and that any follow-up action taken is documented (decontamination, use of shielding) such that any contamination remains below specified limits.

9. Notify RSO/UHP of fixed contamination (i.e., contamination that persists despite decontamination efforts)
10. Procure, dispose and maintain an inventory of all radioactive materials in accordance with University policy
11. Maintain security of radioactive materials to prevent the unauthorized removal in accordance with University policy
12. Notify RSO/UHP **prior** to acquiring:
 - Equipment containing radioactive sealed sources such as:
 - Analytical balances,
 - Liquid scintillation counters
 - Electron capture detectors (ECDs) for gas chromatographs
 - Lead paint analyzers
 - Moisture density gauges
 - Irradiators
 - Equipment capable of producing ionizing radiation such as:
 - Analytical x-ray units
 - Diagnostic x-ray machines
 - Veterinary x-ray units
 - Electron Microscopes
 - Particle Accelerators
13. **Immediately report** spills (major incidents) and/or contamination of laboratory personnel to REHS directly. After normal working hours contact the Campus Police.
14. **Loss or improper disposal of radioactive materials must be reported immediately to REHS.**

Failure to comply with the requirements specified in this guide and other University policies may result in enforcement action.

C. Permit Amendments

The Committee can grant amendments to active radioactive material permits such as increases in possession limits, additions/deletions of authorized laboratories, additions of new radionuclides, additional protocols, changes in chemical forms of previously approved material, etc.

Authorees desiring an amendment to their permit shall submit a written request to the RSO/UHP stating the desired change and its justification. The RSO/UHP will review the amendment and submit their findings to the Committee for consideration. If the amendment is granted, a revised Radioactive Material Permit will be issued by the RSO/UHP on behalf of the Committee.

1. Policy on Human Use

The University's NRC license prohibits ANY use of radioactive materials in or on humans. No human use experiments will be approved.

The use of ionizing radiation (e.g., from x-ray machines) on humans must first be approved by the IRB, REHS and potentially by the NJDEP. Currently, the NJDEP prohibits the intentional exposure of humans without a prescription from a licensed medical doctor. Generally speaking, research information may be gathered incidentally to the clinical application of radiation to humans, but may not be the sole purpose without prior approval from the NJDEP.

2. Animal/In-Vivo Work

The University Animal Care and Facilities Committee (UACFC) reviews and approves all protocols involving animals. Protocols involving the use of radioactive materials, irradiators, or x-rays machines are forwarded to REHS. REHS will review each protocol on an individual basis and submit its evaluation form “In-Vivo Study Using Radioactive Material”, to the Committee or to the UACFC directly if committee approval is not required. The form “In-Vivo Study Using Radioactive Material” is available in the Appendices and on the REHS web page.

The evaluation provides protocol specific guidance on items such as:

- Training requirements
- Posting of cages and rooms
- Disposal of animals and associated radioactive wastes
- Free release of equipment
- Survey frequency and documentation

Committee approval is required when:

- Animal use was not approved as an authorized special procedure in the original radioactive material permit application
- The radionuclide or activity are not currently authorized
- The protocol presents a significant variation on currently accepted research practices

3. Field-Environmental Use of Radionuclides:

The intentional disposal or release of radioactive material into the environment, i.e. the release of radioactive materials into rivers or streams for research purposes, is strictly prohibited. Such use requires the approval of both the NRC and the Committee. A detailed copy of your protocol needs to be submitted to REHS several months in advance so that the necessary approvals may be obtained.

4. Gamma Irradiators

Use of sealed source irradiators requires pre-approval by REHS and special training. Should you require the use of one of our self-shielded irradiators, contact REHS for specific requirements and training information.

D. Permit Expiration and Renewal

Radioactive material permits expire two years from the date of issuance, at which time they must be renewed for uninterrupted use of radionuclides. Each renewal is valid for two years. REHS will contact the Authoree approximately one month prior to the expiration date with instructions on how to renew the authorization.

E. Posting Requirements

The principal investigator is responsible for the proper posting of laboratories, equipment rooms, and other work areas where hazardous materials, including radioactive materials, may be used or stored.

Each laboratory or area where radioactive materials are used or stored must be posted at the entrance with a “**CAUTION RADIOACTIVE MATERIALS**” sticker. The following information should be listed on the Caution sign:

1. The primary contact in case of an emergency. This may be the room supervisor, lab manager, lab technician or Authoree.
2. A secondary contact if the primary contact is not available in an emergency.
3. The contacts' name, campus address (building and room number), and a campus phone number should be listed and kept current.

Refrigerators, freezers, storage areas, and containers in which radioactive materials are stored or transported must have a visible label with the radiation warning symbol and the words **“CAUTION RADIOACTIVE MATERIALS”**. The label should also indicate the radionuclide and the quantity (activity) in the container. Radioactive warning labels should be removed from containers if they are empty and not contaminated.

Laboratory equipment, such as flasks, beakers, centrifuges, etc., that contain radioactive materials or are contaminated, must be labeled with radioactive warning labels or tape.

Areas in the laboratory where radiation levels might expose a person to 5 mrem in one hour at 30 centimeters from the radiation source must be posted with the sign **“CAUTION RADIATION AREA”**.

F. Termination and Reactivation of Authorization

A permit will be terminated when: the Authoree leaves the employment of the University, upon request of the authoree or as the result of an enforcement action by the RSC.

A permit may be inactivated upon request if an Authoree has stopped using radioactive materials for an extended period. Inactive status relieves the Authoree of routine requirements such as the quarterly inventory report, monthly contamination surveys or “No Use” statements, annual radiation safety training, etc.

To request an inactivation, complete the “Laboratory Clearance Form” and fax it to REHS. This form is available in the Appendices and on the REHS web page. REHS staff will assist the Authoree with waste disposal and arrange for an inactivation or decommissioning survey.

The original permit can be reactivated at a later time with minimal effort by:

1. Making a written request to reactive the permit, and
2. Ensuring the Authoree and radiation workers attend radiation safety refresher training prior to anticipated start date

G. Radiation Worker Responsibilities

A Radiation Worker is authorized to work with radioactive materials under the auspices of a radioactive material permit and is responsible to:

1. Attend radiation safety training at the required frequency
2. Adhere to regulations, license conditions and guidelines pertaining to the safe handling of radioactive materials
3. Report any abnormal occurrence, such as a spill or significant contamination to the Authoree and to REHS immediately
4. Gain approval of the Authoree and REHS before making changes to experimental protocols
5. Ensure the security policy for radioactive materials is enforced at all times

IV. TRAINING

Effective training is an integral part of a safety program. Each individual working with radioactive materials must be informed of the potential hazards present in their work area. Radiation safety training outlines safe work practices and regulations that contribute to a safe and compliant workplace. A schedule of trainings is available on the REHS web page.

A. Initial Radiation Safety Training

Prior to beginning work with radioactive materials, prospective Authorees and radiation workers must attend an initial orientation. This training covers the basics of radiation science, interactions with matter, safe handling procedures, methods to reduce internal and external radiation exposure, emergency procedures, survey requirements, etc. An examination is given at the conclusion of the orientation to ensure attendees have mastered the concepts. A passing grade of 75% is required.

Upon successful completion of Initial Radiation Safety Training, a radiation worker will be added to the Authoree's radioactive material permit.

B. Annual Refresher

All Authorees and Radiation workers must attend annual refresher training each calendar year following successful completion of Initial Radiation Safety Training. Refresher training sessions are available in-person and in an online format available on the web page.

Failure to satisfy the refresher training requirement may result in a Notice of Violation and suspension of radioactive material delivery until the training requirement is satisfied.

C. Lab-Specific Training

Each Authoree is responsible for providing each new radiation worker with laboratory or experiment specific training to supplement the Initial orientation. This training is critical for the safe use of licensed material in your laboratory.

REHS is available to provide "in-services" upon request. Generally, REHS personnel are available to provide general training to lab staff as well as critique protocols involving radioactive materials with regards to the safe handling of those materials. These trainings are meant to supplement, but not replace the experiment-specific trainings provided by the authoree or his/her designee.

V. ORDER, TRANSFER, AND RECEIPT OF RADIOACTIVE MATERIALS

A. Ordering Radioactive Materials

REHS must be notified of ALL incoming radioactive materials (e.g. purchases, gifts, samples from collaborative institutions).

Radioactive material purchases from a vendor (e.g., Amersham, Perkin Elmer) are made through the Rutgers Integrated Administrative System (RIAS). Regular purchase orders must be created for the purchase of radioactive materials. A Quick or "Q" order will not be processed. A Standard Operating Procedure (SOP) for ordering radioactive materials through RIAS is available on the REHS website.

Please Note:

1. The University's NRC license number (29-05218-28) and the Authoree's name and 4-digit authorization number must be indicated in the description section.
2. The REHS address must be used as the destination for all radioactive shipments. The address is:

Rutgers, The State University of New Jersey
REHS
27 Road 1, Bldg. 4086
Piscataway, New Jersey 08854-8036
Attention: Authoree name & number

3. Notify REHS by phone or through our web page of each radioactive material order. The following information must be provided: authoree name and number, purchase order number, date ordered, building name, room number, vendor, radionuclide, and quantity. This serves to facilitate processing and ensures the material will be delivered that day.

IF A VENDOR OR CARRIER DELIVERS A RAM PACKAGE DIRECTLY TO YOUR LAB, DO NOT OPEN THE PACKAGE! CALL REHS IMMEDIATELY AT 732-445-2550!

B. Receipt of Packages Containing Radioactive Materials

ALL packages containing radioactive materials must be delivered to REHS. The major radioactive material vendors (e.g., MP Biomedicals, Amersham, Perkin Elmer Life Science, etc.) are instructed to ship all radioactive material to the REHS address only.

Radioactive material packages are recorded and surveyed for external contamination and radiation levels upon receipt. REHS verifies the authoree is authorized for the radionuclide and the authorization limits are verified. Authorees exceeding their possession limits will be denied receipt of the radioactive materials package until the discrepancy is resolved or arrangements are made for a radioactive waste pickup.

Radioactive materials package are delivered directly to the lab on the day of receipt, or in accordance with the Authoree's instructions. REHS must obtain a signature from an authorized user in order to deliver the package. Each lab should keep a copy of the delivery form for at least one year. REHS also provides an inventory log sheet for the Authorees use. This form provides the activity REHS assigned, chemical form and space to record usage and disposal information. As a condition of accepting the radionuclide, the Authoree and radiation workers must adhere to the Package Opening Procedures, outlined below.

1. Accepting a radioactive material package:
 - Only lab personnel who have been to radiation safety training are qualified to receive and open radioactive material packages
 - Inspect the packaging slip
 - Verify the package belongs to your laboratory
 - Verify the radionuclide and activity are correct
 - Place the package in a secure area such as a locked refrigerator or a lockbox if it will not be opened right away

2. Removing the “pig” and the stock vial:
 - Wear gloves, lab coats and safety glasses
 - Use shielding if necessary (lucite or plexiglass shielding for high energy beta emitters such as P-32 and lead shielding for gamma emitters such as I-125)
 - Verify the label on the primary vial has the correct radionuclide activity and volume
 - Wipe test both the plastic or lead pig and stock vial
 - For H-3 you must count the wipes in a liquid scintillation counter
 - For radionuclides other than H-3, wipe the pig and stock vial and hold the wipe up to the appropriate meter (a pancake probe for C-14, P-32 and S-35 or a sodium iodide probe for I-125)
 - If the meter survey or LSC results of the vial wipe are consistent with background, place the material in a secure area
 - If the results are above background, contact REHS for assistance

3. Disposal of Boxes and Packing Material:
 - Survey the packing material for contamination with the appropriate survey meter (see above). Note: this is not necessary for H-3.
 - If meter survey results are consistent with background, continue with the procedure, if meter survey results are above background, dispose of the packaging material in your solid radioactive waste container and contact REHS
 - Verify the box is completely empty
 - Deface any radioactive symbols or appearance of the words “radioactive material” before disposing into regular trash.

C. Transfer of Radioactive Materials

1. Transfer within the University

Authorees who wish to transfer radioactive materials to another authoree within the University must complete and submit an Isotope Transfer Form (available in the Appendices and on the REHS web page) prior to transferring the material. Once approved, the Authoree shall use a secondary container and transfer the radioactive material by walking it from one location to another. REHS will update each Authoree’s inventory based on the Isotope Transfer Form data.

Research staff are prohibited from transporting radioactive material by motor vehicle and are prohibited from offering radioactive material for transport to a commercial or private carrier due to Department of Transportation (DOT) regulations.

2. Transfer outside the University

All radioactive material shipments must conform with DOT and NRC regulations. Therefore all shipments of radioactive materials leaving Rutgers University must be approved, packaged and shipped by REHS. REHS will also obtain the authorization of

the Radiation Safety Officer at the receiving institution and request a copy of the receiving institutions radioactive materials license.

Contact REHS at least two days in advance to ensure the necessary arrangements can be made. REHS requires the following information:

- Radionuclide
- Activity
- Chemical form
- Package requirements (e.g. dry ice, blue ice, ambient)
- “Ship to” or recipient information (i.e., name, address, telephone number)

Research personnel must prepare an inner package according to REHS’ guidance that may include dividing the samples into two or more packages. REHS will pick up the inner package, complete the packaging and shipping papers and arrange for delivery. The Authoree is responsible for covering any charges associated with the radioactive material shipment.

D. Inventory

The University as a NRC licensee is required to maintain an accurate inventory of all radioactive materials present. Therefore, each Authoree is required to maintain an adequate inventory log and have knowledge of the various forms and quantities of radioactive materials present in their laboratories. REHS staff will check inventory logs during quarterly radiation safety inspections.

Every calendar quarter, REHS requires each authoree to complete a quarterly inventory verification report (IVR). All transactions that took place during the previous quarter are listed on the IVR. These include; delivery of radioactive materials, removal of radioactive waste, transfers of radioactive material to another authoree within the University, transfers of radioactive material to another institution, and correction of data entry errors.

Authorees must review the IVR, compare it to their current inventory and if correct, sign and date it prior to returning a copy to REHS. If there are errors, the appropriate corrections should be made on the report along with a short explanation. REHS will make the necessary changes, which will be reflected on the next quarterly IVR.

Failure to return a signed copy of the inventory form in a timely manner will result in the suspension of delivery of radioactive materials. Delivery will be reinstated upon receipt of a signed copy of the inventory report.

Useful tips for keeping an accurate inventory include:

- Radioactive packages: Keep ALL paperwork associated with an incoming radioactive material delivery.
- Utilize the “Radionuclide Inventory Log” provided with each radioactive material delivery
- Waste Cards: Always keep a copy of the yellow card associated with waste pickups
- Pay careful attention to the Start Date and End Date on the IVR. Only transactions that occur within the reporting dates noted will appear.
- When ordering short half-lived nuclides, the vendors usually ship more than the ordered activity. REHS assigns the actual activity received to the Authoree inventory, not the amount that was ordered. Laboratories need to keep track of the total amount received.
- Activity in waste containers REMAINS ON THE AUTHOREE’S INVENTORY. Waste is only deducted from the inventory after it is physically removed from the lab.
- Radioactive decay that occurs while the nuclide is in the possession of the Authoree is not taken into consideration.

VI. SECURITY OF LICENSED MATERIALS

The US Nuclear Regulatory Commission and the NJ Department of Environmental Protection require that radioactive materials be secured against unauthorized removal. All radioactive materials must be secured or under the immediate control and surveillance of the user. Each Authoree is responsible for maintaining the security of radioactive materials under their authorization.

Security of radioactive materials at Rutgers University shall be achieved by any combination of the following:

- Locking laboratories where radioactive materials are used or stored when staff is absent.
- Locking storage areas for radioactive materials (cabinets, refrigerators, freezers).
- Maintaining surveillance of radioactive materials while they are in use.
- Challenging unauthorized entry into the lab. Question all visitors as to the nature and purpose of their visit.

VII. PERSONNEL MONITORING

A. Occupational Exposure Limits

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 (see chart below). This limit is called the “maximum permissible exposure.” It is the responsibility of each individual to keep his/her radiation exposure ALARA, and to avoid exposure to radiation when such exposures are unnecessary.

**Maximum Permissible
Annual Occupational Exposure Limits**

Part of Body	Radiation Worker Limits (mrem/year)
Whole body, head, trunk, active blood forming organs	5,000
Lens of eye	15,000
Extremities	50,000
Single organ dose	50,000
Skin of whole body	50,000

B. Dosimetry

The University shall monitor exposures to radiation and radioactive materials at levels sufficient to demonstrate compliance with the occupational dose limits as specified in Title 10, Code of Federal Regulations, Part 20.

As required by the Nuclear Regulatory Commission (NRC), and the New Jersey Department of Environmental Protection (NJDEP), the University shall monitor occupational exposures to radiation and shall supply and require the use of individual monitoring badges to:

- Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in 20.1201(a)
- Individuals entering an area designated as a “Radiation Area”
- Individuals who use x-ray units
- Declared pregnant workers

This policy precludes the need for dosimetry for most University personnel. A determination as to which individuals require monitoring will be made by the University Health Physicist on a case-by-case basis, based on the potential hazard and exposure histories for such uses. REHS usually issues dosimetry to those who:

- Perform radio-iodination protocols using I-125 or I-131
- Perform experiments such as cell labeling utilizing at least 1 mCi of P-32 at one time
- Use of most x-ray producing machines
- Use of gamma emitters other than iodine

Whole body badges must be worn to provide an indication of the maximum dose received by the trunk of the body. Ring dosimeters should be worn so that the portion containing the LiF ‘chip’ is facing in the direction of the radiation source. This chip is located behind the nameplate on the badge. The ring should be worn under the glove of the hand that holds the radiation source most frequently.

Radiation dosimeters are not assigned to all individuals who work with or around sources of ionizing radiation. The energies of the most commonly used radionuclides are of insufficient energy to be detected by the dosimeters. This is not a risk to the worker under normal conditions because these radiation types are not penetrating enough to cause a deep dose. Examples of these radionuclides are H-3, C-14, P-33 and S-35. Although the radiations from these radionuclides are not capable of delivering a “deep” dose, care must still be taken to insure that none are deposited internally (ingested or inhaled) or deposited on the bare skin. The use of proper engineering controls and personal protective equipment (PPE) should minimize this small risk. Performing surveys and hand washing should mitigate any consequences if skin contaminations were to happen.

Radiation badges provide legal documentation of external radiation exposure received while working with radioactive materials. Care should be taken to make sure that badges do not become contaminated with radioactive materials. Lost or misplaced badges should be reported immediately to REHS in order to receive a replacement. Under no circumstances should workers wear a dosimeter belonging to another individual. It is also important to return your badge quarterly during the radiation badge exchange period. A complete list of Dosimetry Rules and Limitations for research staff is available in the Appendices and on the REHS web page.

All quarterly and annual exposure reports are maintained at REHS. REHS will distribute a “Form 5 –Occupational Exposure Record For A Monitoring Period” to any individual who received a measurable dose in the previous calendar year. This excludes approximately 90% of the badged population at the University, since most doses are “ND” meaning Non-Detectable by the dosimeter. Individuals may contact REHS at any time during the year to obtain a copy of their dosimetry records.

It takes approximately four to six weeks to have badges exchanged, mailed and processed by our vendor. In the event an individual’s dose exceeds our internal ALARA limits (10% of the NRC’s limits), the University Health Physicist or a member of his/her staff will contact the individual and an investigation will be initiated to ensure ALARA principles are being utilized. A measurable dose below the Occupational Exposure limits is not a violation, nor does it imply work practices are not appropriate.

C. Pregnant Workers

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, especially during the first trimester of pregnancy. This can be a concern since many users are unaware of their pregnancy during the first month or two of gestation. Hence, the NRC requires that all occupationally exposed workers be instructed in the potential health risks associated with prenatal radiation exposure.

As defined in 10 CFR 20.1003, a “declared pregnant woman” means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception. The maximum permissible exposure to the fetus of a declared pregnant worker during the gestation period is 10% of the NRC’s annual limits or 500 mrem. An effort should be made to maintain monthly doses below 50 mrem in order to prevent exposure variations. There are very few laboratories at the University where radiation levels are high enough that a fetus could potentially receive a dose that approaches these limits.

If a radiation worker becomes pregnant, she is advised to declare her pregnancy in writing. This can be done by email or by filling out (and signing) an application for a monthly fetal monitoring badge. At this time the prenatal exposure limits take effect. If she wishes, a pregnant worker may meet with a member of REHS to assess her potential radiation exposure and measures to keep her exposures ALARA. Early declaration of a pregnancy is encouraged and confidentiality is maintained at all times. A pregnancy declaration form is available in the Appendices and on the REHS web page.

If notification of a pregnancy is not made in writing, the radiation exposure limits remain at the occupational limits of 5,000 mrem per year. An individual may also “un-declare” her pregnancy in writing at any time.

D. Exposure Limits for the General Public

Visitors to a radiation laboratory who are not classified as occupational radiation workers by the University, lab workers who are not trained in radiation safety, custodial and maintenance staff, and any non-radiation worker are all considered members of the general public.

In accordance with 10 CFR 20.1301, members of the general public shall not receive a radiation dose in excess of 100 mrem in any one year or a dose from external sources of 2 mrem in any one hour. In the laboratory this can be achieved by: storing radioactive materials appropriately, labeling all radiation sources and instruments, using appropriate shielding, cleaning up spills promptly and educating other staff when they enter lab.

E. Bioassays

Conditions of our license issued by the NRC require that bioassays be provided for workers using certain types and amounts of radionuclides. Bioassays shall be performed:

- Individuals performing iodinations of I-125 or I-131 are required to obtain a thyroid bioassay 24-72 hours post iodination
- Individuals handling greater than 100 mCi of tritium (H-3) must submit a urine sample to REHS for bioassay within 24 hours of the handling. This bioassay must be performed each time this quantity of tritium is handled.
- In the event of a spill, release or contamination incident, REHS may require further bioassays from an occupational worker.
- At the discretion of the UHP or RSO.

VIII. INCIDENTS AND EMERGENCIES

A. What is an incident or emergency?

Incidents may occur during the use of radioactive materials, such as spills, contamination of the worker or work area and accidental release into the air. When an incident occurs, the worker must first make a judgment as to whether the incident is a **minor** or **major** incident. The chart on the following page will help you to make this determination. When in doubt, call REHS. **There are no penalties for reporting an incident or requesting assistance no matter the circumstances or actions leading up to the incident.**

B. Notifications

The proper response to an emergency depends upon a thorough understanding of the magnitude of risks, priorities for action and the application of common sense. When calling REHS to report a spill, the following information should be provided:

- Location of incident
- Authoree
- Name and telephone number of person reporting
- Persons contaminated or exposed, estimate of amount on skin
- Radionuclide involved
- Activity
- Volume of released material
- What steps have been taken so far

In the event of a spill or emergency during normal business hours, REHS should be contacted directly. After business hours contact University Police at 6-911 for Piscataway & New Brunswick, 5111 in Newark and 6111 in Camden.

C. Basic Procedures

When radioactive material is in an unwanted or unplanned location, it is called contamination. This may be on floors, equipment, work areas, people or areas outside the authorized laboratory. Fortunately, most radioactive contamination is easy to clean to background levels in a reasonable time and with reasonable cost. Concentrated liquid decontaminating agents are available from most scientific suppliers. Other foam cleaning products, such as bathroom or kitchen cleaners are just as effective at a much lower cost. Many other agents will work to clean radioactive contamination that has been resistant to other cleaners. The following are two formulas that have been found to work.

SURFACE DECONTAMINATION SOLUTIONS

1. For I-125
25 g Sodium Thiosulfate
2 g Sodium Iodide
in 1 Liter of 1M Sodium Hydroxide
2. For P-32, etc.
50 mL Triton
20 g EDTA
100 mL decontamination detergent (such as Count-Off, RadCon)
Add enough distilled water to make 1 liter of solution.

Emergency Procedures for Radiation Incidents

Minor Incident	Major Incident (Any of the following conditions)
<ul style="list-style-type: none"> • < 0.1 mCi of RAM (Radioactive Material) • No personal contamination • Localized contamination • No spread of RAM outside licensed areas • Proper tools and knowledge available for clean up 	<ul style="list-style-type: none"> • > 0.1 mCi of RAM • Skin and/or clothing contamination is involved (any quantity) • Airborne RAM is thought to be present • Large areas are contaminated • Contamination has spread outside licensed areas • Personnel injury or fire • Unsure of what to do, or how to do it
Laboratory Guidelines	Laboratory Guidelines
<ul style="list-style-type: none"> • Stop source of the spill • Warn other personnel • Survey and mark the affected areas • Minimize exposures • Begin cleanup • If area cannot be cleaned, notify REHS • Document incident in laboratory survey book 	<ul style="list-style-type: none"> • Treat life threatening injuries first • Evacuate and lock (or post) laboratory if airborne or fire hazard exists • Perform first aid, if applicable • Remove contaminate clothing • Measure and record amount of contamination on skin with applicable meter and wash area gently with warm soap and water • Warn other personnel • Notify REHS and Authoree • If after hours, please call Campus Police • Try to prevent the spread of contamination, if possible • Await the arrival of REHS

Emergency Contacts

DURING BUSINESS HOURS: CALL REHS AT 732-445-2550

AFTER HOURS: CALL RUTGERS POLICE
 6-911 Piscataway & New Brunswick
 5111 Newark
 6111 Camden

D. Skin Decontamination

REHS must be notified immediately if any personal contamination (contamination on clothing, skin or any part of the body) occurs or is suspected. It is important to keep a record of the following:

- The amount of contamination found – the maximum meter reading in CPM – be careful to note the scale you are using
 - The approximate area of skin contaminated – mark it with a pen or marker
 - The time the contamination was discovered and the time the contamination was removed
 - Record the survey meter used and set it aside for REHS inspection
1. Personnel who have identified contamination should begin decontamination by washing the effected areas with warm water and mild soap.
 2. Personnel assisting in decontamination will use necessary precautions and protective clothing to prevent the spread of contamination to their person or the surrounding area.
 3. Decontamination will be performed in a manner to avoid spreading it to other parts of the body. All cleaning should be done from the periphery of the contaminated area towards the center.
 4. When washing a contaminated area of the body, care must be taken to prevent abrasions or cuts of the skin to prevent internal contamination. Do not use a scrub brush.
 5. Wash skin with mild soap and lukewarm water only. Wash repeatedly until REHS personnel arrive, the contamination has been removed, or further washing will abrade the skin.
 6. When drying an area of the skin that has been decontaminated by washing, do not rub the skin; pat it dry.
 7. In the event that the affected area is not being effectively decontaminated – do not try any alternate decontamination methods until REHS arrives. REHS will make the determination for further actions.

IX. PRACTICAL RADIATION PROTECTION

A. The “Golden Rule”

Prior to leaving the laboratory after working with radioactive materials, each individual shall: Monitor his/her person and work area with the appropriate survey instrument and thoroughly wash his/her hands. Following this simple rule will mitigate or eliminate the vast majority of radiological contamination events and significantly minimize their impact.

B. Required Surveys

Whenever unsealed sources of radioactive material (i.e., liquid solutions in vials, test tubes, flasks, etc.) are handled, it is possible to contaminate laboratory benches, floors and equipment, as well as hands, skin and clothes. Every laboratory where radioactive materials are handled must be surveyed for radioactive contamination on a regular basis. Surveying the lab for contamination is essential to prevent the spread of contamination to equipment and personnel working in the laboratory and will help prevent inadvertent internal depositions of radioactive materials as well as reduce external exposures.

1. Daily Surveys (Post-Experiment Contamination Surveys)

Daily surveys must be performed after every use of unsealed radioactive materials, with the exception of H-3. These surveys should be performed with a portable survey instrument but may be performed via wipe test if an appropriate instrument is not available. An appropriate survey instrument for performing daily surveys is considered to be a Ludlum Model 3 with a pancake Geiger-Mueller (G-M) detector or equivalent. End-window G-Ms are unacceptable as they lack sufficient sensitivity for mid to low energy beta emitters. For low energy gamma emitters such as I-125 and Cr-51, an acceptable instrument is a Ludlum Model 3 with a sodium iodide (NaI) probe. REHS performs an efficiency check annually on all survey meters. If you need assistance in purchasing a meter, or suspect that your meter is not working properly, please contact REHS for advice.

A post-experiment contamination survey must include the following:

- **Personal Survey:** Gloves, hands, skin, lab coat, shoes, and clothing.
- **Equipment Survey:** Any equipment used during the radioactive material experiment such as centrifuges, vortexes, gel dryers, etc.
- **Bench Survey:** All benches that were used during the experiment and drawers that were handled.
- **Floor Survey:** The floor in front of all areas used during the experiment.
- **Trash Survey:** Survey the non-radioactive trash to ensure no radioactive material was accidentally disposed of in the regular trash.

Daily surveys must be documented at least once each day radioactive material is used on the Post Experiment Contamination Survey Form. The surveyor shall include the date and their initials. A copy of this form is available in the Appendices and on the REHS web page.

Any area with survey results above background should be carefully examined for contamination. If contamination is confirmed, the area must be decontaminated and re-surveyed. This should be noted on the Post Experiment Contamination Survey Form. Areas such as the inside of labeled waste containers or mild contamination on the inside of labeled centrifuges need not be decontaminated. In the event you are unable to decontaminate an area, or are unsure of how to proceed, please contact REHS directly.

2. Portable Survey Instruments

When using portable survey instruments, it is essential that the proper techniques be employed to ensure accurate results. The guidelines below must be followed when using a survey instrument:

- Use the correct detector or probe
 1. GM or pancake probe for P-32, P-33, C-14, S-35
 2. NaI probe for I-125
- Check the battery and ensure the instrument is operable by holding the detector near a known source of radiation.
- Ensure that you select the proper scale on the instrument for conducting the survey. Always start with the lowest scale available, i.e., x0.1 or x1 scale. Select higher range scales as necessary to obtain maximum readings if contamination is detected.
- Hold the detector approximately 1 cm above the surfaces to be monitored. If the detector is too far away, underestimation of activity may occur. If the detector is too close to the surfaces being monitored, contamination of the detector may occur.
- Survey slowly; the sensitivity of the detector is inversely proportional to increasing survey speed. As a rule of thumb, survey 1 to 2 inches per second.
- Do not cover the probe with parafilm or Saran wrap. These covers will act as a shield and decrease the detection capability of the meter.
- Use the instrument's audible response while conducting surveys. The audible response is faster than the meter scale indication. You should listen for any increases in "clicks" above background levels.
- Make sure the meter is set on F for fast and not S for slow. This provides a "real-time" detection response.
- **Important:** Remember that H-3 is such a low-energy beta that it cannot be detected with a survey meter. Monthly or weekly wipe tests are the only available method to detect H-3 contamination.

3. Monthly Wipe Surveys

A monthly wipe test must be performed each month that radioactive material is used to ensure the lab is free of contamination. Counting of wipes should be performed in a liquid scintillation counter or gamma counter, if appropriate. The efficiency and Minimum Detectable Activity (MDA) of the counter must also be calculated. Records of monthly wipe surveys, raw data, and efficiency and MDA calculations of the counter are to be maintained on file in the laboratory and will be reviewed by REHS during quarterly laboratory inspections. If no radioactive material was used in a given month, a wipe test is not required, although "No Use" statements must be documented in the monthly wipe test logbook.

At the discretion of the University Health Physicist, a laboratory may be required to perform bi-monthly wipes based on the risk posed by a specific radionuclide, the level of activity utilized or past evidence of undetected contamination in the laboratory.

REHS has designed an Excel spreadsheet that can be used to assist the laboratory when performing the appropriate calculations for, and the proper documentation of, their monthly wipe surveys. It is an invaluable tool for the researcher. Please refer to the REHS web page.

The wipe test is a measure of removable (loose) surface contamination. Prior to taking wipe tests or samples, an initial check for contamination should be performed using a survey meter to draw attention to areas requiring possible decontamination. Use a survey meter with an appropriate detector to survey bench tops, fume hoods and other work areas. If any areas are above background levels, then decontamination procedures might be necessary prior to taking wipe

samples.

Using filter paper disks or cotton swabs, take a series of wipes using moderate pressure from working surfaces where contamination may be expected to exist. Each wipe should be numbered and the location where they are taken shown on a diagram (map) of the room. The wipes can be moistened with alcohol or water and should be rubbed with moderate pressure over a surface area of about 100 square centimeters (the approximate size of a dollar bill). Use the "S" technique to wipe a large area of the bench or floor. Analyze the wipes using the appropriate counter. A background or blank vial and the appropriate standard should also be run with the sample wipes in order to calculate efficiency, net dpm, and MDA. These calculations are summarized in the Appendices. If any H-3 is used in that month, a H-3 standard should be used to calculate efficiency and MDA. If the lab is using P-32, C-14, S-35 or P-33, a C-14 standard can be used for efficiency and MDA calculations. If other radionuclides such as Cr-51 are used, contact REHS to discuss the appropriate standards to use.

The amount of removable contamination shall be recorded in units of disintegrations per minute (dpm) /100 cm². The action limit for decontamination is 100 dpm/100 cm² above background. This means that any wipe over 100 dpm/100 cm² needs to be decontaminated with RadCon or similar cleanser and resurveyed to confirm removal of any contamination. The cleaned and re-wiped samples should be kept in the monthly wipe book along with the previous wipes.

Refer to the following procedure for liquid scintillation counting:

- Deposit wipe sample in a clean scintillation vial
- Fill vial with scintillation cocktail to cover wipe or swab
- Tightly cap the vial
- Invert the vial a few times
- Count the samples, a background or blank sample and the appropriate standard vial for one minute
- Review the printout and perform the calculations. A sample result with greater than 100 dpm/100 cm² above background must be cleaned and re-wiped until the area is below the action limit.

Important Notes:

- *If laboratory personnel cannot remove contamination, contact REHS.*
- *Remember, the lab may utilize the Excel spreadsheet available on the REHS website.*

4. Weekly Surveys

Weekly wipe tests must be performed if more than 10 mCi of H-3 is utilized in one week. Since a G-M detector with a pancake probe cannot detect the low energy beta emitted by H-3, only a wipe survey is effective in detecting H-3 contamination. These surveys shall be documented and the records held with either the Daily Survey Forms and/or the monthly wipe tests.

5. Immediate Surveys

Immediate surveys must be performed following iodination procedures. These surveys of your person and work area must be documented on the Iodination Survey Form provided to you along with the air-sampling pump. The form is also available in the Appendices and on the REHS web page. The completed survey must be returned to REHS when the iodinator obtains his/her thyroid bioassay. Please refer to Safe Handling Procedures, Section X, for more details regarding the requirements surrounding iodination procedures.

C. Preventing Internal Exposures

Radioactive materials may be deposited internally, typically through one of four routes of entry: inhalation, ingestion, absorption through the skin and injection. While external radiation hazards typically arise from gamma emitters, all forms of radioactive materials may deliver internal doses, with alpha and beta emitters contributing a large percentage of their energy to the total dose. Internal depositions may be acute or chronic. The actual dose delivered due to a unit uptake will vary widely between the nuclides and individuals. The physical half-life of the nuclide and the biological half-life of the chemical form it is attached to will greatly affect the total dose delivered.

Work practices shall be designed to reduce the risk of internal exposure. If you suspect you have had an internal exposure contact REHS IMMEDIATELY during normal business hours or contact the Campus Police outside normal business hours. Depending on the metabolic characteristics, the ability of the REHS staff to collect bioassays soon after the suspected uptake may be vital in calculating the delivered dose.

Measures to prevent or eliminate internal depositions include, but are not limited to:

- Informing REHS whenever you propose to work with volatile sources of licensed materials.
- Work with volatile sources in an approved, properly functioning fume hood or filtered glove box.
- Utilize proper PPE when handling unsealed sources of licensed material, e.g., lab coat, long pants and closed toed shoes, double gloves, etc.
- Handle contaminated sharps with care and dispose of them only within properly labeled sharps containers.
- Thoroughly survey your person and work area with the appropriate survey meter after working with licensed materials and wash your hands prior to leaving the laboratory.

D. Preventing External Exposures

External hazards arise when radiation from a source external to the body has the ability to penetrate the body and deposit energy, causing a “dose”. These exposures can be from gamma, x-rays, neutrons, or beta particles. The exposure is dependent upon both the type and energy of the radiation.

Most beta particles do not normally penetrate beyond the skin, but when sufficiently intense, can cause skin and/or eye damage. Very energetic beta particles, such as those emitted by P-32, can penetrate several millimeters into the skin. Shielding is needed in order to reduce the external radiation exposure. Typically, a maximum of ½ inch thick sheet of Plexiglas or acrylic is an effective shield for most beta particles.

***Note:** The vast majority of radionuclides utilized in a University setting are beta emitters. Most beta emitters, if deposited on the surface of the skin, may cause locally high skin doses. Remember, the occupational dose limit for the skin is only 50,000 mrem/yr. It is very important to survey your person and wash your hands after every use of radioactive materials to prevent an inadvertent overexposure.*

Alpha particles, because of higher mass, slower velocity and greater electrical charge compared to beta particles, are capable of traveling a few inches in air and rarely penetrate the outer dead layer of skin. Therefore, alpha particles are typically not an external radiation hazard.

X-rays and gamma rays, along with neutron radiation, are very penetrating, and are of primary importance when evaluating external radiation exposure and usually must be shielded. The onset of first observable effects of acute radiation exposure, diminished white blood cell count, may occur at a dose of approximately 100 rads (which is approximately equal to 100,000 mrem) of acute whole body radiation exposure. The Lethal Dose for 50% of the human population (LD₅₀) is

about 400 rads whole body exposure, assuming no medical intervention.

Exposure to external radiation may be controlled by limiting the working time in the radiation field, working at a distance from the source of radiation, using shielding between the worker and the source, and by using no more radioactive material than is necessary.

External radiation exposures can be reduced using three basic tools: **time, distance and shielding.**

Time

Radiation dose is directly proportional to exposure time. Therefore, one of the simplest methods of reducing exposure is to limit the time spent exposed to the radiation. Below are a few suggestions to help reduce exposure time:

1. Preplanning - Conduct 'dry runs' of the experiment without using radioactive materials, gather all equipment and supplies needed to perform the experiment prior to the start of work, and conduct the work efficiently.
2. Postings - Signs posted in radioactive materials work areas will help to keep non-essential personnel away from the radiation field and remind researchers to avoid the area except when absolutely necessary.

Distance

The intensity of a point source of gamma radiation is inversely proportional to the square of the distance (Inverse Square Law). Therefore, greater distance means less dose. Do not increase the distance to the point where dexterity or control of the material is compromised. The use of remote handling tools and the storage of radioactive material in a remote area are extremely effective in reducing radiation exposure when practical. In a research setting, a small increase in distance can greatly reduce exposure to hands or other extremities. Doubling the distance from the source (in most cases this may only be a few inches) will reduce the exposure by a factor of four. Tripling the distance will reduce the exposure by a factor of nine.

Shielding

1. Gamma radiation- Gamma radiation is diminished in intensity by any given absorber, but not completely stopped. Materials having a high atomic number (Z) can absorb more gamma radiation than lighter elements. Lead is a frequently used shielding material. A convenient way to calculate the thickness of shielding necessary is to use the concept of Half Value Layer (HVL) which is the amount of shielding which reduces the incident radiation by one-half.
2. Alpha and Beta particles- Due to the fact that alpha and beta particles deposit so much energy over such a short distance they are easy to shield. Alpha particles require little or no shielding as they travel only very short distances in air. Low density (Z) materials, such as Plexiglas or acrylic, make excellent shielding for beta particles. Thin layers of high density materials such as lead (lead foil) must be avoided when shielding high-energy beta emitters such as P-32. This configuration may cause the production of Bremsstrahlung radiation (x-rays) and potentially INCREASE the external hazard of the beta source.
3. Neutrons - The properties of neutrons vary depending on their energies. Because of this, the type of shielding may vary. Generally, any hydrogen-rich material such as paraffin will suffice. Additional types of shielding may be required due to the production of radioactive materials via interactions with neutrons. If work with neutron producing materials/equipment is going to occur, REHS must be contacted prior to commencement of work.

X. SAFE HANDLING PROCEDURES

A. General Radiation Safety Practices

- All personnel must be current with training requirements (initial and refresher training) to use radioactive materials.
- Appropriate personal protective equipment (PPE) shall be used when working with radioactive materials; buttoned lab coats, eye protection and double gloves at a minimum. PPE should be removed before leaving the laboratory.
- Dosimeters shall be worn appropriately by the assigned individual and exchanged in a timely manner. Dosimeters shall be stored in a low radiation environment when not in use (i.e. desk drawer).
- Eating, drinking, smoking and the application of cosmetics are prohibited in the laboratory. Food, beverages and utensils shall not be stored or disposed in the laboratory.
- Use appropriate shielding and other dose reduction techniques to minimize radiation exposure in the laboratory.
- Use absorbent padding or work in a spill tray – clearly mark the work area “Caution Radioactive Material”.
- All operations involving potentially volatile radioactive materials should be conducted in a properly operating fume hood.
- Each authoree must have available a calibrated and operable radiation survey instrument appropriate for the radionuclides in use.
- Radioactive materials being moved between authorized locations of use shall be placed in appropriate containers to contain spills and/or prevent exposure. Each container shall be placed in a secondary container and transported on a cart when practical.
- Radioactive waste shall be disposed of according to REHS guidelines. Drain disposal of radioactive waste is strictly prohibited.
- Provide for the security of all radioactive materials in accordance with University policy.
- Wash hands thoroughly and survey yourself and your work area after working with radioactive material.
- Report all accidents involving radioactive materials to REHS or Campus Police after working hours.

B. Special Procedures

Certain chemical reactions may generate radioactive gases thereby increasing the risk of inhalation by the user. Procedures such as iodinations using I-125 or I-131 and reduction experiments using sodium borohydride (H-3) require prior approval of the Radiation Safety Committee due to their increased potential for volatilization.

1. Iodination Procedures

I-125 is widely used for the preparation of tracers for immunoassays and other procedures for the detection and localization of biological samples. I-125 exhibits certain physical chemical and biological properties that necessitate special handling to ensure researcher safety and regulatory compliance.

The gamma and x-ray emissions of I-125 are easily shielded by lead foil and internal exposure by inhalation is the primary hazard. When inhaled, 67-70% of the activity will be deposited in the body and ~30% of that deposition will be taken up by the thyroid and retained with an estimated effective half-life of 40 days. An ingestion of 40 uCi or an inhalation of 60 uCi of I-125 would cause an individual to reach the NRC's annual exposure limit.

Approval Process

The RSC must approve iodinations as an authorized procedure on the radioactive material permit.

REHS approves each iodinator on an individual basis. REHS will review the protocol and observe each iodinator during a "dry-run". As part of the approval process, each iodinator is responsible to:

- Obtain a baseline thyroid bioassay from REHS prior to use
- Apply for whole body and extremity dosimeters
- Perform dry runs of the experiment (without radioactivity) to become familiar with the procedure.
- Submit a copy of the iodination procedure to be followed

PROCEDURE NOTES: Stock vials should be vented with a charcoal trap (contact vendor) to remove any build-up of iodine in the headspace of the vial. Iodinations should be "closed system" with additions and removals being performed with a Hamilton syringe. The volatility of iodine is enhanced at low pH, do not add acid and carefully review the manufacturer's package instructions.

- Submit the room location and the desired hood for review

PROCEDURE NOTES: The hood must be vented directly to the roof and ideally be directly ducted and not ganged with other hood ducts. The hood shall have a demonstrated face velocity of 80 -100 linear feet per minute at a sash height of no less than 18 inches. The face velocity shall be determined annually and documented on the stickers affixed to each hood. This data will be used to calculate effluent data.

- Arrange for REHS to observe the last dry run. The iodination shall be performed with mock versions of all buffers, solutions, equipment, etc., that are to be used in the "real" procedure. REHS will provide an air-sampling pump and filters and provide instruction on their use.

- Upon successful completion of the above procedures, REHS will authorize the individual for iodinations by entering the applicant into the air monitoring program and the approved hood into the database.

Work Place Preparation and Requirements - Particular attention should be paid to glove selection and its chemical compatibility with the reagents involved.

The following personal protective equipment is needed:

- Safety glasses
- Lab coat – disposable is recommended
- Double gloves – sleeve guards recommended

All iodination procedures must be performed in an approved fume hood.

A low energy gamma probe with a current calibration must be operable and turned on during the procedure.

REHS will deliver the I-125 and a calibrated air-sampling pump. The air-sampling pump shall be used for one labeling procedure only.

A contamination survey must be performed and documented immediately after the iodination procedure. The survey forms will be delivered with the I-125 and pump. The post iodination survey form is also available in the Appendices and on the REHS web page.

Radioactive waste containers may require shielding – REHS can help determine shielding requirements during the approval process. Consider making a solution of Iodo-Mix (0.1M NaI, 0.1 M NaOH, 0.1M Na₂S₂O₃) to have for application to spills, to rinse equipment and to add to the liquid waste containers to help stabilize the radioiodine and reduce volatilization.

The iodinator must obtain a thyroid bioassay 24-72 hours post-iodination from REHS. The responsibility for scheduling this bioassay lies with the researcher. Failure to have the bioassay performed in the appropriate time frame will result in a Notice of Violation.

2. Reduction Procedures

H-3 sodium borohydride is employed in the labeling of carbohydrates. It also has applications in organic synthesis to reduce aldehydes, ketones, acid chlorides and anhydrides, and in industrial application to reduce carbonyls, peroxides and metal ions, purification and removal of color, odor and oxidation precursors in organic chemicals. REHS approves each applicant on an individual basis. REHS will review the protocol and observe each applicant during a “dry run”. As part of the approval process, each applicant is responsible to:

- Submit a baseline urine sample to REHS prior to use (if more than 100 mCi of H-3 is to be utilized).
- Performing dry runs of the experiment to be performed (without radioactivity) to become familiar with the procedure.
- Submitting a copy of the procedure to be followed including vendor or supplier.
- PROCEDURE NOTES: *Containers should be tightly closed; volatility is enhanced at high pH. The applicant shall include estimated rates of incorporation.*
- Submitting the room location and the desired hood for review.
- PROCEDURE NOTES: *The hood must be vented directly to the roof and ideally be directly ducted and not ganged with other hood ducts. The hood shall have a demonstrated face velocity of 80 -100 linear feet per minute at a sash*

height of no less than 18 inches. The face velocity shall be determined annually and documented on the stickers affixed to each hood. This data will be used to calculate effluent data.

- Arrange for REHS to observe the last dry run. The reduction shall be performed with mock versions of all, solutions, equipment, etc., that are to be used in the “real” procedure.
- Upon successful completion, REHS will authorize the individual for this procedure by entering the applicant into the air monitoring program and the approved hood into the database.

Work Place Preparation

Particular attention should be paid to glove selection and its chemical compatibility with the reagents involved. The following personal protective equipment is needed:

- Safety glasses
- Lab coat – disposable is recommended
- Double gloves

All procedures must be performed in an approved fume hood – a closed system may be employed depending on activity.

A post-contamination survey must be performed and documented immediately after the procedure.

The researcher must submit a urine sample 12-72 hours post-reduction to REHS.

3. Other Common Uses Involving Potentially Volatile Sources

Experiments with commonly authorized radionuclides (S-35 methionine, H-3 as tritiated water and occasionally C-14 labeled organic solvents) may produce volatile materials. Any chemical or physical form that readily volatilizes or evaporates into the air must be considered a potential airborne risk. The researcher must be cognizant of this potential and plan the experiments accordingly and contact REHS for guidance. The Committee requires that all operations involving potentially volatile radioactive materials should be conducted in a properly operating fume hood. The University must tabulate the amount of radioactive emissions released to the environment each year. It is very important that if procedures have the potential to release airborne radioactive materials that REHS accounts for these releases.

S-35 Handling Procedures

The labeling reaction for S-35 methionine generates a methyl mercaptan reaction that liberates HCl and $^{35}\text{SO}_2$. With S-35 labeled amino acids the volatile component is very soluble in water; thus the water present in incubators used for cell culture can become contaminated including the interior surfaces of the incubator. Incubators shall be included in the monthly contamination wipes performed by the lab and it is recommended that they be checked for contamination after each use.

S-35 labeled amino acids should be thawed in a fume hood. It is recommended that they be vented using a charcoal packed syringe. These syringes are available from the vendor.

XI. WASTE DISPOSAL PROCEDURES

REHS provides radioactive waste removal, management and disposal services. The following is a description of the radioactive waste removal services provided by REHS. Radioactive waste is defined as any waste that is contaminated with or contains radioactive material.

A. Dry Solid Waste

Dry waste consists of paper, gloves, plastic containers, and other forms of contaminated laboratory waste.

Container Types

- Dry waste can be collected in 30 or 55-gallon drums provided by REHS.
- Dry waste may also be collected in waste containers purchased by the laboratory provided they meet the following criteria:
 - Containers must be rigid (e.g. plastic, metal or heavy gauge cardboard – bags alone are not adequate)
 - Containers must be double lined (REHS can provide plastic liners)
 - Containers must have a lid or cover

Container Labeling

Dry waste containers should be properly labeled with:

- A radiation symbol
- The words “Caution Radioactive Materials”
- Properly completed Radionuclide Disposal Forms (yellow cards) indicating the authoree name, the date(s) waste was place into the container, the radionuclide content of the waste and the activity present in the containers. These forms may be located near the containers such that it is apparent which container they are associated with.

Waste Acceptance

Dry waste containers should not contain the following:

- Free Standing Liquids
- Biohazardous Material or Biohazard Bags
- Sharps (see section entitled Sharps)
- Metals
- >5% PVC (weight or volume)
- Sealed Sources
- RCRA/TSCA hazardous wastes
- Explosives
- Pyrophoric materials

Do not commingle dry solid waste with other waste streams (liquid, liquid scintillation vials, animal/biological).

Dry Solid Waste Segregation Scheme

Solid waste must be segregated based on half-life and according to the following scheme:

- Waste with half life ≤ 15 days (e.g. P-32)
- Waste with half life > 15 days and ≤ 120 days (e.g. I-125, S-35, P-33, Cr-51)
- Waste with half life > 120 days **^3H and ^{14}C only**
- Waste with half life > 120 days **other than ^3H and ^{14}C** (e.g. Ca-45, Cl-36)

B. Liquid Waste

Liquid waste consists of freestanding liquids only, such as radionuclides dissolved or suspended in water, including solutions of proteins, buffers, cell media, etc.

Container Types

- Liquid waste should be collected in 1.0 or 2.5 gallon (~ 5 and 10 liter) polyethylene carboys provided by REHS.
- Liquid waste may be collected in containers furnished by the laboratory provided they meet the following criteria:
 - Containers are plastic (not glass)
 - Containers have properly fitting lids (screw on)
 - Containers are stored in secondary containment
 - Containers are used with the understanding that they will not be returned for reuse

Container Labeling

- Liquid waste containers should be properly labeled with:
 - The radiation symbol
 - The words "Caution Radioactive Materials"
 - Properly completed Radionuclide Disposal Forms (yellow cards) describing the authoree name, the date(s) that waste was placed into the container, the radionuclide content of the waste and the activity present in the container.

Waste Acceptance

- Liquid waste containers should not be overfilled
- Do not commingle liquid waste with other waste streams (solid, liquid scintillation vial, animal/biological)
- Liquid waste containers should be stored in secondary containment
- Liquid waste should have a pH between 6 and 9
 - Neutralization should be done as the last step in experimental procedures prior to disposal
 - If waste has been added to the container and has a pH range ≤ 2 or ≥ 12.5 , please follow mixed waste procedures
- If your waste contains any etiologic agents you must notify REHS

Liquid Waste Segregation Scheme

Liquid waste must be segregated based on half-life and according to the following scheme:

- Waste with half-life ≤ 15 days
- Waste with half-life > 15 days and ≤ 120 days
- Waste with half-life > 120 days **^3H and ^{14}C only**
- Waste with half-life > 120 days **other than ^3H and ^{14}C**

Drain disposal of radioactive liquid wastes is strictly prohibited in the laboratory. All liquid wastes must be offered to REHS for disposal.

C. Mixed Waste

Mixed waste consists of waste that is radioactive and also has an additional hazardous component(s), (e.g. flammable, corrosive, reactive, and poisonous). Some common procedures performed in the laboratories which may generate mixed waste are: HPLC analysis, phenol / chloroform extractions, the use of certain liquid scintillation cocktails and precipitation reactions utilizing trichloroacetic acid. A list of non-hazardous scintillation cocktails is available in the Appendices. If mixed waste is currently generated in the lab and you have not contacted REHS, please do so immediately.

If you anticipate generating mixed wastes:

- Please contact REHS prior to the generation of mixed waste to help establish disposal procedures and waste minimization plans.
- Label mixed waste with:
 - The radiation symbol
 - The words, "Caution Radioactive Materials"
 - Properly filled out black and white "Hazardous Waste Label"
 - Properly filled out yellow radionuclide disposal form
- Note all hazardous and non-hazardous constituents in Section III of the yellow radionuclide disposal form.
- Mixed wastes may be extremely expensive to dispose. Waste minimization should be a critical component of your experimental protocols.

D. Liquid Scintillation Vials

Container Types

- Liquid Scintillation Vials can be collected in 30 or 55-gallon drums provided by REHS.
- Liquid Scintillation Vial waste can be collected in containers purchased by the laboratory provided that they meet the following criteria:
 - Container is rigid (capable of containing liquid)
 - Container has a capacity of 10 gallons or less
 - Container is double lined (REHS can provide plastic liners)

LSVs, if generated in small amounts, may be stored in the original cardboard tray that the empty vials come in provided that the tray follows all the marking and labeling requirements of a waste container.

Container Labeling

Liquid scintillation vial waste containers should be properly labeled with:

- The radiation symbol
- The words “Caution Radioactive Materials”
- Properly completed Radionuclide Disposal Forms (yellow cards) describing the author name, the date(s) that waste was placed into the container, the radionuclide content of the waste and the activity present in the container
- Properly filled out black and white hazardous waste label if the cocktail used is not on the “safe” cocktail list available in the Appendices

Waste Acceptance

- Do not commingle liquid scintillation vial waste with other waste streams (solids, liquids, and animal/biological).
- Do not place small vials of stock solutions with scintillation vials.
- Liquid scintillation vials must be capped. If the liquid were to leak, it may degrade the plastic liner.
- Containers must not be overfilled; the lid must fit properly.
- Use approved non-hazardous scintillation fluid unless otherwise authorized. A list of approved or “safe” cocktails is available in the Appendices and the REHS web site.
- Liquid scintillation vial waste containing ^3H and ^{14}C in concentrations greater than 0.05 microcuries/gram may require special consideration (roughly 1 mCi/30 gallon drum and 2.0 mCi/55 gallon drum). Please contact REHS if you plan on generating liquid scintillation vial exceeding these activities.
- If one vial has significantly more activity (~ 0.5 mCi or greater) than the rest of the vial waste, please keep it separate for pick-up.
- Yellow Radionuclide Disposal Forms should be marked with the name brand of the liquid scintillation cocktail.

Liquid Scintillation Vial Segregation Scheme

Liquid scintillation vial waste must be segregated by radionuclide according to the following scheme:

- Waste with half life ≤ 120 days
- Waste containing only ^3H and/or ^{14}C
- Waste with half life > 120 days other than ^3H and ^{14}C

Note: Please attempt to keep the total activity of waste in any liquid scintillation vial drum to less than 2 mCi. If you need to exceed this limit, please inform REHS.

E. Animal Carcasses and Biological Waste

Animal carcasses must remain frozen prior to disposal. REHS has limited storage capacity for this waste type. The Authoree shall have facilities to accommodate the full volume of his/her anticipated waste for at least three months.

Container Types

- Animal carcasses may be stored in freezers in sealed double bags.

Container Labeling

- Animal carcasses and biological waste containers should be properly labeled with:
 - The radiation symbol
 - The words “Caution Radioactive Materials”
 - Properly completed Radionuclide Disposal Forms (yellow cards) describing the authoree name, the date(s) that waste was placed into the container, the radionuclide content of the waste and the activity present in the container.

Waste Acceptance

- Do not commingle animal/biological waste with other waste streams (solids, liquids, liquid scintillation vials).
- Keep animal carcasses and tissues frozen until removal by REHS personnel.
- Prevent sharp edges from puncturing the bags.
- Animals contaminated with ^3H and ^{14}C at a concentration less than 0.05 microcuries per gram can be disposed of as non-radioactive by REHS. When the radioactivity is concentrated in certain organs, these parts can be removed for radioactive waste disposal as tissues, and the remaining carcass can be treated as non-radioactive waste if the remaining activity for ^3H and ^{14}C is less than 0.05 microcuries per gram.
- Animals containing nuclides with a half-life of less than 120 days will be held for decay to background.
- Animals that are known to contain active pathogens, as well as radioactive materials, must receive special attention; REHS must be notified.

Biological/Animal Carcass Segregation Scheme

Biological/Animal Carcass waste must be segregated by half-life according to the following scheme:

- Waste with half-live < 120 days
- Waste containing only ^3H and/or ^{14}C
- Waste with half live > 120 days other then ^3H and ^{14}C

F. Sharps

Sharps consist of any sharp object contaminated with radioactivity (see list below):

- Sharps must be collected only in approved sharps containers.
- Do not cap syringes before placing in the sharp containers.
- Sharps containers must be sealed and properly labeled as radioactive waste.
- Sharps containers should be presented for disposal as radioactive waste. Do not place sharps containers into solid waste containers.
- The generator is responsible for purchasing sharps disposal containers.
 - Please ensure all biohazard symbols and words are crossed out if no such hazard is present.
- The presence of loose sharps intermixed with dry waste represents a great hazard to REHS personnel and constitutes a serious violation that could result in the revocation of the Authoree's permit.
- Sharps include the following items:
 - Hypodermic needles
 - Syringes (including those without needles)
 - Pasteur pipettes
 - Scalpel blades
 - Blood vials
 - Culture dishes
 - Slides
 - Cover slips
 - Broken glass
 - Needles with attached tubing

G. Radionuclide Disposal Forms (Yellow Cards)

The terms of the University's license requires detailed records of receipt, use and disposal of radioactive materials. All radioactive materials must be accounted for. To facilitate the tracking of radionuclides, a radionuclide inventory log should be kept for each nuclide used. Always make sure that the total activity in the lab does not exceed the maximum possession limit for that radionuclide. Always compute the balance on hand (mCi). This information is essential for the completion of the yellow disposal cards.

A yellow disposal card shall accompany each container of radioactive waste. If multiple authorees share a single container, it is important that one card for each laboratory be present on the container. Disposal cards should be completed as waste is placed into the container. Do not wait until the waste container is full to complete the disposal card. Please fill in all the required information with careful attention to the following:

Section I.

Authoree: Name of the authorized user.

Auth. No. 4-digit number assigned to the authoree.

Pick Up Date: To be completed by REHS upon removal.

BLDG: Building in which waste is located.

Room No.: Number of the room in which waste is located.

Container Volume: Volume of the container in which waste is located.

Section II.

Date: Date nuclides were placed into the container.

Isotope: Radionuclides present in the container.

Chemical Name: Name of the radiolabeled chemical

Chemical Form: General chemical family to which the radiolabeled chemical belongs.

Activity: Radioactivity (mCi) contained in each waste entry.

Section III.

Chemical Name: Chemical names of remaining chemicals (other than those noted in section II).

Total Activity: Activity totals for each radionuclide entered in Section II.

Authoree Signature: Signature of laboratory employee who is responsible for collection of radioactive waste.

Things to remember while completing Yellow Disposal Cards:

- Do not perform any correction for decay.
- Enter the activities in millicuries.
- Clearly state the chemical name and chemical form of the radiolabeled chemical (Section II).
- List each chemical component; other than radiolabeled chemicals recorded in Section II, and its percentage (Section III). Remember that the objective is to identify mixed waste, e.g., waste that is both hazardous and radioactive. This is especially important for liquid waste.
- For liquid scintillation vial waste indicate the name brand of the liquid scintillation cocktail.
- Do not forget to sign the card.
- Keep the card clean and avoid contamination.
- Unless the disposal cards are properly completed, REHS personnel will not pick up the radioactive waste.

H. Request for Radioactive Waste Removal

Removal of radioactive waste takes five to ten working days from the date of request, depending on your location. Please plan accordingly. When you contact REHS, have the following information ready.

- Authoree name and number
- Building and room where waste is stored
- Type of waste (dry, liquid, vials, animal)
- Radiouclides present in waste
- Yellow disposal ticket numbers
- Number and size of containers.

To request a radioactive waste pick-up contact REHS at 732-445-2550 or submit a request for radioactive waste disposal via the web page.

XII. SEALED SOURCES & GENERALLY LICENSED DEVICES

- A. Sealed sources are radioactive sources that are encapsulated in some source of housing such that a release of radioactive material is highly unlikely under normal conditions. For this reason, many of the policies and procedures regarding contamination control are not required. However, many sealed sources have relatively large activities and therefore may present a significant source of external radiation exposure and must be handled with care. Generally, sealed sources are regulated under the University's NRC or NJDEP license.

Generally Licensed Devices (GLDs) are devices that contain a radioactive source and are available to the general public for purchase without a specific license from the NRC or NJDEP. Hence the term "generally-licensed". These devices have safety features engineered into the design and direct handling of the radiation source is not possible under normal operating conditions. Examples include: smoke detectors, gas chromatographs with electron capture devices, self-luminescent exit signs, and liquid scintillation counters

1. Requirements

Possession of any sealed source requires the appropriate authorization from the RSC and REHS. Users must attend training, sources must be labeled, and security must be in place. It is the Authoree's responsibility to ensure that the sources are used according to the regulations. REHS must be notified whenever a sealed source is purchased, transferred, relocated, or disposed.

2. Semi-Annual Leak Tests

Sealed sources must be inspected and tested for leakage under the supervision of REHS at six-month intervals or as specified in the license under which they were acquired.

XIII. RADIATION PRODUCING MACHINES

A. Authorization for Use

For the purposes of this section, the term “radiation-producing machine” refers to x-ray machines of the standard diagnostic and therapeutic types, x-ray diffraction units, x-ray crystallography units, electron microscopes, particle accelerators, and high voltage rectifiers with voltages exceeding 20 KeV. The New Jersey Department of Environmental Protection (NJDEP) regulates the use of radiation-producing devices.

Any person who wishes to be an authoree (one who has administrative control of and responsibility for, a radiation-producing unit) must first complete the “Application for Authorization to Use a Radiation-Producing Machine”. The Application is available in the Appendices and on the REHS web page. The completed form may be sent by campus mail or faxed to REHS. After receipt of the Application, REHS will contact the applicant to set up an appointment to discuss the rules and regulations for radiation producing machines.

B. Acquisition and Initial Inspection

REHS must be notified prior to the acquisition of any radiation-producing machine to ensure adequate facilities and trained personnel are available. After receipt of a radiation-producing machine and prior to its use, REHS will schedule an appointment to inspect and survey the unit. The initial inspection will include (but is not necessarily limited to) the following:

- Survey for radiation leakage
- Testing lights for fail-safe characteristics
- Issuance of dosimetry
- Assess training compliance of all users
- Evaluate the operating manual and/or standard operating procedure (SOP)
- Creation of log book
- Assess alignment SOP and approval of qualified individuals (if applicable)
- Interlock checks
- Security of unit
- Safety of unit
- Posting of appropriate signs and labels

REHS will interpret the NJDEP regulations and provide assistance with compliance. Upon completion of training and a satisfactory inspection, REHS will register the unit with the NJDEP and grant authorization to the applicant. The authorization permits only the use of the specific machine identified in the application and only in the location for which the initial inspection was made. If the authoree wishes to obtain additional units, he/she will need prior approval from REHS. Any new units under the Authoree’s permit will require an initial inspection of the unit as outlined above. REHS will provide dosimetry for new users and perform exchange of same each quarter.

C. **Authoree Responsibilities**

The authoree for a radiation-producing machine has the following responsibilities to satisfy NJDEP regulations and University policies:

- Under the direction of REHS, ensure that the radiation-producing machine meets all requirements of the NJDEP regulations.
- Cooperate with REHS to conduct semi-annual (or annual in the case of electron microscopes) inspections of the radiation-producing machines under his/her authorization.
- Correction of any non-compliance issues noted during inspection.
- Ensure proper use and exchange of dosimetry (e.g. whole body and extremity badges) for persons assigned to his/her authorization.*
- Ensure all users of radiation producing machines are in compliance with training requirements.
- Maintain a user log including names, dates and times of use.
- Provide and maintain a written, detailed SOP for the safe operation of the unit and ensure that it is available to each user. Ascertain that all users are properly trained in the use of that specific unit.
- Provide and maintain a written, detailed SOP for alignment procedures (if applicable). All users who perform alignment must be approved by REHS.

*Please note that if badges are not exchanged for 2 cycles for any particular person, the authoree may be required to pay for the quarterly charges and lost badge fees (as charged by the dosimetry vendor).

The authoree should notify REHS immediately in the following circumstances:

- If an over-exposure to radiation is indicated or suspected.
- Upon failure of an interlock or fail-safe device.
- Before any machine is moved, disposed or transferred.
- When change in experimental design could result in significant radiation exposure or hazard.
- If there are new workers in the lab who wish to use the unit.
- If there is a new person who wishes to perform alignment and/or if there is a new alignment procedure.

Training consists of successful completion of the Rutgers/RWJMS Online X-Ray Training provided by REHS through our web site. The authoree and his or her authorized users will be required to complete the training and quiz prior to operation of any radiation-producing machine. Once the REHS training is complete, the user will need to complete a badge application (available on the REHS web site). Additionally, the authoree is required to provide hands-on, unit-specific training for each user.

D. **Relocation and/or Repairs**

The NJDEP requires notification and a re-survey of any unit that is moved. Prior to relocating a radiation-producing machine, the authoree should contact REHS for approval. Once the unit is approved for relocation, it will be subject to an initial inspection as outlined in the above procedure. If any unit is repaired or modified, the authoree is required to call REHS to re-survey the unit. Prior to disposal or transfer of any radiation-producing machine, the authoree must contact REHS for the appropriate instructions.

E. Inspections and Enforcement

Upon completion of bi-annual (or annual) inspections, REHS will send each authoree a copy of the inspection report. Any issues of non-compliance will be noted on these reports. The authoree is expected to correct any issues in a timely manner. If the inspector notes any major non-compliance issues, and/or repeat minor non-compliance issues, a Notice of Violation (NOV) may be issued. A written response is required, within two weeks, outlining the corrective measures taken by the authoree. If two NOVs, are issued within 3 inspection cycles, a Management Meeting may be required, at the discretion of the Radiation Safety Committee. A Management Meeting will include the authoree and at least two of the following: University Health Physicist, the Radiation Safety Officer, and a member(s) of the Radiation Safety Committee. If at any time, the unit is deemed to pose an immediate safety hazard, REHS will prohibit the use of the unit until corrective actions have been taken.

An Authoree who knowingly allows an individual to use a unit that poses an immediate safety hazard or fails to prevent the use of the unit via adequate administrative controls, will have their authorization suspended pending a Management Meeting.

Major non-compliance issues are defined below:

- Disposal or relocation of a radiation-producing machine without notifying REHS.
- Failure to comply with REHS requests to repair or add warning lights.
- Use of a unit that has not been inspected by REHS.
- Failure to report the acquisition of a new or transferred radiation-producing machine.
- Use of a unit that has been classified as “in storage-out of use” without prior notification to REHS.
- Unauthorized individuals performing alignment without prior approval of REHS.
- Use of a unit by personnel who have not been trained and/or have not obtained dosimetry.

Examples of a minor non-compliance issue are:

- Non-compliance with REHS requests to perform bi-annual (or annual) inspections.
- Failure to keep and/or use a written log book.
- Failure to produce an operator’s manual and/or a written SOP for the unit.
- Failure to provide a means to prevent unauthorized use (e.g. – locked door or keys left in unit).
- Dosimetry is not worn consistently when operating the unit.
- Sharing of radiation badges.

If an authoree or user does not understand any of the policies noted above, please contact REHS for clarification.

APPENDICES