RUTGERS UNIVERSITY RADIATION SAFETY GUIDE

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RADIATION SAFETY GUIDE
CONTENTS

VI. SECURITY OF LICENSED MATERIALS

VII. PERSONNEL MONITORING

A. Occupational Exposure Limits
B. Dosimetry
C. Pregnant Workers
D. Exposure Limits for the General Public
E. Exposure Limits for Minors
F. Bioassays

VIII. INCIDENTS AND EMERGENCIES

A. What is an Incident or Emergency?
B. Notifications
C. Basic Procedures
D. Skin Decontamination

IX. PRACTICAL RADIATION PROTECTION

A. The "Golden Rule"
B. Required Surveys
C. Preventing Internal Exposures
D. Preventing External Exposures
E. General Lab Safety Practices

X. SPECIAL PROCEDURES

A. Use of Volatile Materials
B. Procedures with Biohazardous Materials

XI. WASTE DISPOSAL PROCEDURES

A. Dry Solid Waste
B. Liquid Waste
C. Mixed Waste
D. Liquid Scintillation Vials
E. Animal Carcasses and Tissues
F. Biohazardous Waste
G. Sharps
H. Radionuclide Disposal Forms (Yellow Cards)
I. Request for Radioactive Waste Removal

XII. SEALED SOURCES AND GENERALLY LICENSED DEVICES

A. Requirements
B. Semi-Annual Leak Tests
C. Labeling Requirements

XIII. RADIATION PRODUCING MACHINES

A. Authorization for Use
B. Acquisition and Initial Inspection
C. Authoree Responsibilities
D. Relocation and/or Repairs
E. Inspections and Enforcement

APPENDICES

Characteristics of Commonly Used Radionuclides
Fetal Dosimetry Program
Dosimetry Rules & Limitations
Efficiency/MDA Calculations
Radioactive Material Transfer Form
Inspection Checklist Explanation
Lab Clearance Checklist
Approved Liquid Scintillation Cocktails
Post Experiment Survey Form (Daily Survey Form)
Post Iodination Survey Form
Radionuclide Inventory Log
Survey Meter Information
Common Postings & Labels

I. INTRODUCTION AND ALARA POLICY STATEMENT

A. INTRODUCTION

The use of radioactive materials and machine sources of ionizing radiation are regulated by the New Jersey Department of Environmental Protection, Bureau of Radiological Health (NJDEP). Rutgers University has a license of broad scope from the NJDEP 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 governed by 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.

Rutgers University has appointed a Radiation Safety Committee (RSC) 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 **A**s **L**ow **A**s **R**easonably **A**chievable. 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". 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 all university personnel 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 the 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 Senior 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. REHS staff assists the RSC as necessary.

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. Oversee 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 may include sections of the program such as: the policies and procedures for controlling and maintaining inventory, 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 New Jersey Department of Environmental Protection (NJDEP), as long as these changes are not in conflict with specific license conditions or specific NJDEP regulatory requirements.

5. Adjudicate any differences between authorized users and REHS.

The RSC typically meets 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 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 RSC

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, 10 CFR 20, and NJAC 7:28.

7. Periodically meet with and report to university administration and the RSC.

The university community is encouraged to contact the RSO or any radiation safety staff member with any questions or concerns regarding the use of ionizing radiation. Email addresses of the radiation safety staff are available on the REHS 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 regular basis according to our license requirements. During these inspections REHS will perform the following at a minimum:

- Check post-experiment surveys and monthly wipe tests
- 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.

3. Radioactive Waste Disposal and Pick-up

All radioactive wastes must be disposed through REHS.

DRAIN DISPOSAL OF RADIOACTIVE WASTE 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 Section XI, Waste Disposal Procedures.

4. Personnel Radiation Monitoring

Staff working with certain radioactive materials or 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 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 during radiation safety inspections. REHS can assist with repairs and, if necessary, coordinate with vendors to arrange repair service.

7. Radiation Safety Training

All authorees and radiation workers are required to complete:

- Initial radiation safety training prior to beginning work with radioactive materials and,
- Refresher training annually. In-person refresher is offered in the third and fourth quarters of the year at various locations around the university. Online refresher training is also offered throughout the year via the REHS website.

8. Emergency Response

REHS provides emergency response to incidents involving radioactive materials 24 hours a day, 7 days a week. 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 NJDEP has two basic premises 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 NJDEP expects the university to have a rigorous program of laboratory safety audits. It is important to realize that the NJDEP holds the institution responsible for the actions of the individuals working here.

With this in mind, REHS inspects each authorized laboratory on a regular basis according to our license requirements. 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 report is forwarded to the authoree.

The self-identification and correction of violations by the university is well regarded by the NJDEP. Conversely, the failure to identify violations or the failure to correct those identified can lead to enforcement action by the NJDEP. Whenever possible, REHS works proactively 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 Class I or Class II. Class I 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 NJDEP. Class II violations do not generally have the potential to cause immediate risk to health or welfare, however multiple or repeat occurrences may lead to the university being out of compliance with its license conditions.

The following are examples of Class I violations:

- Failure to perform and/or document monthly wipe tests or post-experiment surveys
- Failure to use the proper personal protective equipment
- Failure to meet 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 after a major incident
- Improper radioactive waste disposal and/or loss of licensed material
- Failure to secure licensed source material

The following are examples of Class II 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 to maintain a functional survey meter

2. Authoree Response to NOV

Authorees must provide a written response to the RSO 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 RSO detailing why he/she believes the NOV should be rescinded. If the RSO and the authoree cannot agree on the disposition of the NOV, the matter will be referred to the RSC for adjudication.

3. Potential Sanctions

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

At the discretion of the RSO and chair of the RSC, a management meeting may be required for the following:

- Two Class I violations issued within a twelve month period. 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 sanctions are warranted.
- Multiple Class I violations are incurred during a single inspection.
- Multiple and/or repeated Class II violations are incurred within twelve months.
- If three Class I NOVs are issued within a twelve month period, sanctions will most likely be imposed on the authoree's permit.

Sanctions could include any or all of the following:

- Required in-service training by REHS.
- Probationary status: May use licensed material, but inspection frequency will be increased for the term of probation and suspension will be likely should a major or repeated NOV be issued during the probationary term.
- Suspension of delivery of licensed materials may be imposed: 1) If an authoree fails to attend a management meeting within four weeks of notification, 2) During an incident and until the incident has been fully investigated and corrective actions implemented, or 3) At the discretion of the RSO.
- Suspension of the authoree's radioactive materials permit (no delivery and no use of material). Licensed material may be confiscated with concurrence of the RSC. The suspension will be lifted when the RSC is satisfied that the authoree has taken measures to ensure the use of radioactive materials in his/her lab will be in compliance with Rutgers policies and procedures. The duration of suspension will be determined by the RSC.
- Further Class I violations by the authoree's lab within six months of any suspension will likely result in an escalated suspension of the authorization.
- The RSO at his discretion may immediately suspend an authoree's permit. The suspension would remain in force until an emergency meeting of the RSC can be convened.
- 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 Radiation Safety Committee (RSC). Faculty and staff meeting the minimum criteria outlined below shall complete and submit an application package to the Radiation Safety Officer (RSO).

Minimum criteria:

- Hold a faculty or staff position with at least the rank of Instructor, Research Associate, or its equivalent.
- Possess a graduate degree in a physical science, life science, engineering, or medicine; and have 6 months to one year of experience working with radionuclides.
- 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.
- Attend initial radiation safety training.
- It is preferable for candidates to have relevant experience with the specific isotopes requested. However the RSC will make a determination on a case by case basis.

The RSO or his/her designee 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 on behalf of the RSC and will be valid for a period of two years. The permit specifies the name of the authoree, the lab(s) in which radioactive materials may be used, the radionuclide(s) to be used, and the maximum quantity of each radionuclide permitted.

The "Application to Use Radioactive Materials" can be found on the REHS website.

B. AUTHOREE RESPONSIBILITIES

The authoree is responsible for the safe use of all radioactive materials obtained under his/her permit and for ensuring that all radiation workers under his/her 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 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) such that any contamination remains below specified limits
9. Notify the RSO 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 unauthorized removal in accordance with university policy.

12. Notify the RSO **prior** to acquiring:

    Equipment containing radioactive sealed sources such as:
    - Analytical balances,
    - Liquid scintillation counters
    - Electron capture detectors 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 RSC 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 stating the desired change and its justification. The RSO will review the amendment and submit their findings to the RSC for consideration. If the amendment is granted, a revised radioactive material permit will be issued by the RSO on behalf of the RSC.

1. Policy on Human Use

The university's New Jersey Department of Environmental Protection (NJDEP) 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's Institutional Animal Care & Use Committee (IACUC) 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 will liaise with the IACUC and/or authoree and present it to the RSC if approval is required.

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

RSC 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 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 NJDEP and the RSC. 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 self-shielded irradiators requires pre-approval by REHS, special training, and fingerprinting along with a FBI criminal history check. Should you require the use a self-shielded irradiator, contact REHS several months in advance for specific requirements and training information.

D. PERMIT EXPIRATION AND RENEWAL

Radioactive material permits expire two years from the date of issue, at which time they must be renewed to ensure uninterrupted use of radionuclides. REHS will contact the authoree approximately one month prior to the expiration date with instructions on how to renew their authorization.

If radioactive material permits are not renewed in a timely fashion, the RSC and/or the RSO may impose sanctions or restrictions on use including, but not limited to the sanctions detailed in Section II, under Enforcement Policy.

E. POSTING REQUIREMENTS

REHS 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 sign with the **"CAUTION RADIOACTIVE MATERIALS"** sticker. See the Appendices for an example of this sticker. It is the PI's responsibility to fill out a caution sign request form. 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 contact's 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"**. (See the Appendices for an example of this posting).

Laboratory equipment, such as flasks, beakers, centrifuges, etc., that contain radioactive materials or are contaminated, must be labeled with radioactive warning labels or tape (see the Appendices for an example of this posting) or contained in a clearly designated radioactive material use area.

Equipment containing radioactive sources (e.g. liquid scintillation counters, gas chromatographs with electron capture detectors, etc) has separate posting requirements. Please refer to Section XII, Sealed Sources and Generally Licensed Devices.

While not a frequent occurrence at the university, should a laboratory need to utilize large quantities of energetic beta or gamma emitters, additional posting requirements may be necessary. Please contact REHS for an evaluation.

F. TERMINATION AND REACTIVATION OF AUTHORIZATION

A permit will be terminated when: 1) the authoree leaves the employment of the university, 2) upon request of the authoree or 3) as the result of an enforcement action by the RSC. An authoree may also remove a laboratory from his/her permit if radioactive materials will not be used in that laboratory.

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 bi-annual inventory reports, monthly contamination surveys or "no use" statements, annual radiation safety training, etc.

To request a permit inactivation, complete the Laboratory Clearance Checklist and fax or email it to REHS. This form is available in the Appendices and on the REHS website. 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 request to reactivate the permit, and
2. Ensuring the authoree and radiation workers are current with their radiation safety training prior to the anticipated start date.

If renovation work will be done (such as painting, removing floor tiles, moving fixed equipment, etc), REHS must be given two weeks' notice in order to fully decommission the laboratory. Otherwise, if most of the contents of the laboratory will remain and it will not be used for radioactive material use, REHS will inactivate the laboratory. A gray and white "Inactive" sticker will be posted on the door (see the Appendices for an example). This reflects that the lab has been surveyed by REHS and found free of contamination, although inaccessible areas such as walls, under refrigerators and other equipment has not been certified free of contamination.

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 major incident (spill) or significant contamination to the authoree and 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

H. POLICY FOR MINORS WORKING IN AUTHORIZED RADIOACTIVE MATERIAL LABORATORIES

Minors (any person under the age of 18) including students, full-time employees, part-time employees and both paid and un-paid interns are subject to very restrictive limits regarding exposure to ionizing radiation. The NJDEP has set exposure limits for minors at 10% of the annual limit for adults. Therefore, minors working with or near radioactive materials or equipment that produces ionizing radiation may not receive a whole body dose in excess of 500 mrem/year.

You must contact REHS if you intend to have a minor work in your authorized radioactive material laboratory

Generally speaking, if the minor will work in your laboratory but not work directly with radioactive materials or radiation producing machines:

- REHS will review the work to be done by the minor,
- Evaluate your laboratory environment regarding the potential for the minor to receive a radiation dose even though he/she will not work directly with the materials/equipment, and
- Arrange for radiation safety training for the minor.

If you have a person under the age of 18 who wishes to work with radioactive materials, or operate x-ray equipment, please contact REHS **prior to the start of work**. Minors are discouraged from handling licensed materials and operating radiation producing machines, to protect both the minor and the university. If there are compelling reasons for the minor to work with licensed materials, the request will be given consideration. This consideration will include, but is not necessarily limited to:

1. Protocol review by the RSO
2. Initial radiation safety training
3. Parental consent
4. Radiation safety committee approval
5. Authoree certification of hands-on training
6. Authoree certification of all experiments minor will perform
7. Supervision at all times
8. Dosimetry

Minors are not permitted, under any circumstances, to perform radio-iodinations or work with animals in conjunction with radioactive materials.

Please contact REHS if you have a minor working in your radioactive material laboratory.

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. The training schedule is available on the REHS website.

A. INITIAL RADIATION SAFETY TRAINING

Prior to beginning work with radioactive materials, prospective authorees and radiation workers must complete an initial radiation safety orientation. This may be in-person or a combination of in-person and online content. 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 80% 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 TRAINING

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 REHS website. If a lab has received a major Notice of Violation (NOV) in the previous year, the authoree and his/her radiation workers must attend in-person refresher training.

Failure to satisfy refresher training requirements may result in a NOV and suspension of radioactive material delivery until the training requirement is satisfied. If there is a training lapse of 3 years, the radiation worker will be required to attend initial training.

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 personnel are available to provide "in-service" training upon request 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 training provided by the authoree or his/her designee.

V. ORDERING, RECEIPT, AND TRANSFER OF LICENSED MATERIALS

A. ORDERING RADIOACTIVE MATERIALS

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

Radioactive material purchases from a vendor (e.g., Perkin Elmer, MP Biomedicals) are made through the appropriate purchasing system. Regular purchase orders (PO) must be created for the purchase of radioactive materials. A Quick or "Q" order will not be accepted for a radioactive material order. When entering purchase orders, please make sure the authoree's name is on the order. Ensure the PO is coded correctly as a "radioactive order" in the purchasing system.

Please note:

1. The university's NJDEP license number (located on the cover page of this guide) 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 listed on the cover page of this guide.

3. Notify REHS by phone or through our website 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 reduces processing time and ensures the material will be delivered on the day it is received.

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

B. RECEIPT OF PACKAGES CONTAINING RADIOACTIVE MATERIALS

ALL packages containing radioactive materials **must be delivered to REHS**. The major radioactive material vendors (e.g., Perkin Elmer, MP Biomedicals, 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 possession limits are checked. Authorees exceeding their possession limits will be denied receipt of the radioactive material package until the discrepancy is resolved or arrangements are made for a radioactive waste pickup.

Radioactive material packages 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 lab's use. This form lists the activity of the radionuclide received, 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, lockbox, or otherwise secured laboratory) 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 (LSC)
    - For radionuclides other than H-3, wipe the pig and stock vial and hold the wipe up to the appropriate meter (use 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.
    - Verify the box is completely empty
    - 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
    - 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 a Transfer of Radioactive Material form (available in the Appendices and on the REHS website) 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 (or contact REHS for cross campus delivery). REHS will update each authoree's inventory based on the 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 to DOT and NJDEP regulations. Therefore all shipments of radioactive materials leaving Rutgers must be approved, packaged and shipped by REHS. REHS will also obtain the authorization of the receiving institution and request a copy of the receiving institution's 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
- Any additional hazards
- Package requirements (e.g. dry ice, reusable cooler packs, 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 costs associated with the radioactive material shipment.

D. INVENTORY

The university as a NJDEP 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 radiation safety inspections.

Twice per year, an authoree is required to complete and submit an inventory verification report (IVR). All transactions that took place during the previous 6 months 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 submit it 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.

Failure to submit the IVR 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:

- Keep ALL paperwork associated with an incoming radioactive material delivery
- Utilize the inventory log sheet provided with each delivery
- Always keep a copy of the yellow waste 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-lived nuclides, the vendors usually ship more than the ordered activity. REHS assigns the actual activity received to the authoree's inventory, not the amount that was ordered. Personnel 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. Do not account for decay on your IVR.

VI. SECURITY OF LICENSED MATERIALS

The New Jersey Department of Environmental Protection requires 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. Our security policy is a performance based policy where the needs of each individual laboratory will be evaluated during radiation safety inspections. In general, if a laboratory has ingress and egress from anywhere other than the main entrance, then a lockbox or locked refrigerator/freezer will be required for security of source vials.

Security of radioactive materials shall be achieved by a combination of the following:

- Locking laboratories where radioactive materials are used or stored when staff is absent (for laboratories with only one main entrance)
- Locking storage areas for radioactive materials (cabinets, refrigerators, freezers, or utilizing a lockbox)
- 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 New Jersey Department of Environmental Protection (NJDEP). They have been set at a level where apparent injury due to ionizing radiation during a normal lifetime is unlikely (see chart below). 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.

Annual Occupational Dose Limits

Part of Body	Radiation Worker Limits (mrem/year)
Whole body	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 the NRC's Title 10, Code of Federal Regulations, Part 20, as referenced in the NJDEP's regulations NJAC 7:28.

As required by the NJDEP and/or university policy, 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" (defined by the NRC as an area where radiation levels could result in an individual receiving a dose in excess of 5 mrem/hour)
- Individuals who use x-ray units
- Declared pregnant workers
- Minors (those under the age of 18) working with radioactive materials

This policy precludes the need for dosimetry for most university personnel. A determination as to which individuals require monitoring will be made by the Radiation Safety Officer (RSO) on a case-by-case basis, based on the potential hazard and exposure histories for such uses. REHS issues dosimetry to those workers who:

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

Whole body badges are 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 name plate 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 emissions 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 should minimize this small risk. Performing surveys and hand washing should mitigate any consequences in the instance of skin contamination.

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. Avoid placing them in areas where they will be exposed to extreme heat. 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 website.

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 90% or more 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 NJDEP's limits), the RSO 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 <u>not</u> 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 women are unaware of their pregnancy during the first month or two of gestation. Hence, the NJDEP 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. This declaration will remain in effect until the worker withdraws the declaration, in writing, or is no longer pregnant. The maximum permissible exposure to the fetus of a declared pregnant worker during the gestation period is 10% of the NJDEP'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 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 website.

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.

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 workers 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, performing post-experiment surveys, labeling all radiation sources and instruments, using appropriate shielding, cleaning up spills promptly, and educating other staff when they enter lab.

It is important to notify REHS if you are using volatile radioactive compounds in hoods. Prior approval is needed when using H-3 or C-14 gas and performing iodinations. REHS uses these values in calculating exposure limits to the general public.

E. EXPOSURE LIMITS FOR MINORS

For students and employees who are under the age of 18, in accordance with 10 CFR 20.1207, the annual occupational dose limits for minors are 10% of the annual dose limits specified for adult workers in 10 CFR 20.1201. This means that minors who work in radioactive material labs cannot exceed a whole body dose of 500 mrem in any one year.

Please refer to Section III, Subsection H for details of the Policy for Minors Working in Laboratories.

F. BIOASSAYS

Conditions of our license require that bioassays be provided for workers using certain types and amounts of radionuclides. Bioassays are performed for the following:

- 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 or;
- At the discretion of the RSO.

VIII. INCIDENTS AND EMERGENCIES

A. WHAT IS AN INCIDENT OR EMERGENCY?

Incidents may occur during the use of radioactive materials (RAM), 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 repercussions for the timely reporting of an incident or requesting assistance regardless of what the circumstances or actions were 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 (8am to 5pm), REHS should be contacted directly. After business hours, contact campus police by obtaining an outside line and dialing 911. Be sure to indicate to the dispatcher that you have "an incident involving radioactive materials".

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 amount of time and at a reasonable cost. ***Every lab should have appropriate spill cleanup supplies on hand.*** Concentrated liquid decontaminating agents are available from most scientific suppliers. Foam cleansers, 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 l Liter of 0.1M 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 (If all of the following are true)	Major Incident (Any of the following conditions)
• < 100 uCi of RAM (Radioactive Material) • No personal contamination • Localized contamination • No spread of RAM outside licensed areas • Proper tools and knowledge available for clean up	• > 100 uCi of RAM • Any amount of personal contamination (i.e. skin, clothing, and personal protective equipment with the exception of gloves) • Airborne RAM is thought to be present • Large areas are contaminated • Contamination has spread outside licensed areas (labs/storage areas) • Personnel injury or fire • Unsure of what to do, or how to do it
Laboratory Guidelines	**Laboratory Guidelines**
• Stop source of the spill • Warn other personnel • Survey and mark the affected areas • Begin cleanup • If area cannot be cleaned, notify REHS • Document incident in laboratory survey book	• Treat life threatening injuries first • Evacuate and lock (or post) laboratory if airborne or fire hazard exists • Perform first aid, if applicable • Remove contaminated clothing • Measure and record the 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 848-445-2550

AFTER HOURS
CALL RUTGERS POLICE
By obtaining an outside line and dial 911

D. SKIN DECONTAMINATION

REHS must be notified immediately if any personal contamination (i.e., contamination on clothing, lab coats, 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 immediately by washing the affected areas with warm water and mild soap.

2. Personnel assisting in decontamination will use necessary precautions and proper protective equipment (gloves, safety glasses, and lab coats) 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. Post-Experiment Surveys (Daily Surveys)

Post-experiment 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 (GM) detector or equivalent. End-window GMs are unacceptable as they lack sufficient sensitivity for mid to low energy beta emitters. For low energy gamma emitters such as I-125, an acceptable instrument is a Ludlum Model 3 with a sodium iodide probe. During radiation safety inspections, REHS personnel perform operational checks 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 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, refrigerators, 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 Survey Form. The surveyor shall include the date and his/her initials. A copy of this form is available in the Appendices and on the REHS website.

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 Survey Form. Additionally, wipe tests should be conducted to confirm all contamination has been removed. 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
  - GM with pancake probe for P-32, P-33, C-14, S-35, Cr-51
  - Sodium iodide probe for I-125 or Cr-51
- 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 emitter 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 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 Radiation Safety Officer (RSO), 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 website to download a copy of the program.
The wipe test is a measure of removable (loose) surface contamination. If you suspect contamination, 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 disintegrations per minute (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 dpm/100 cm^2. The action limit for decontamination is 100 dpm/100 cm^2 above background. This means that any wipe over 100 dpm/100 cm^2 needs to be decontaminated with RadCon or similar foaming cleanser and resurveyed to confirm removal of any contamination. The cleaned and re-wiped sample results should be kept in the monthly wipe book along with the previous wipe test results.

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 (3-4 ml is usually enough)
- 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 cm^2 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.*
- *In the event multiple high counts are observed, this could be the result of chemiluminescence or static electricity. Try storing the wipe test vials in a dark drawer overnight or wiping with a dryer sheet to see if that solves the problem. Otherwise contact REHS for guidance.*
- *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 GM detector with a pancake probe cannot detect the low energy beta emitted by H-3, only a wipe test is effective for detecting H-3 contamination. These surveys shall be documented and the records held in the monthly wipe test book.

5. Immediate Surveys

Immediate surveys must be performed following iodination procedures. These surveys of your person and work area must be documented on the Post-Iodination Survey Form provided to you upon delivery of your iodine. The form is also available in the Appendices and on the REHS website. The completed survey must be returned to REHS when the iodinator obtains his/her thyroid bioassay. Please refer to Special Procedures, Section X, for more details regarding the requirements surrounding iodination procedures.

Depending on the radionuclide and activities used, other immediate surveys may also be required at the discretion of the RSO.

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. All forms of radioactive material may deliver internal doses. Internally deposited alpha and beta emitters contribute a larger percentage of their decay energy (than gamma emitters) to the total dose. Doses resulting from internal depositions may be acute or chronic. The actual dose delivered due to a unit uptake will vary widely between the radionuclide and individual. The physical half life of the radionuclide 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 that you have had an internal exposure, CONTACT REHS IMMEDIATELY during normal business hours or contact the campus police outside of 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 personal protective equipment (PPE) when handling unsealed sources of licensed material, e.g., lab coat, long pants, 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.

Important 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. Skin contamination that goes undetected may result in an overexposure, causing you to exceed the occupational exposure limits. 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 (LD_{50}) is about 400 rads whole body exposure, assuming there is no medical intervention.

Exposure to external radiation may be controlled by limiting the time spent 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 material work areas will help to keep non-essential personnel away from the radiation field and remind researchers to avoid the area.

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 lower dose. 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. Do not increase the distance to the point where dexterity or control of the material is compromised. The use of remote handing tools and the storage of radioactive material in a remote area are extremely effective in reducing radiation exposure when practical.

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 determine the thickness of shielding necessary is to use the concept of the half value layer which is the amount of shielding which reduces the incident radiation by one half. This value is commonly advertised with various shielding products. Call REHS for assistance in determining shielding requirements for special needs.

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 Plexiglass 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.*

E. GENERAL LAB SAFETY PRACTICES

- All personnel must be current with training requirements (initial and refresher training) to use radioactive materials.
- Appropriate PPE shall be used when working with radioactive materials: buttoned lab coats, eye protection and double gloves. 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 an 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.

X. SPECIAL PROCEDURES

A. USE OF VOLATILE MATERIALS

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 (RSC) 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. 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 New Jersey Department of Environmental Protection's annual exposure limit.

Approval Process:

The RSC must approve iodinations as an authorized procedure on a 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 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 any effluent releases.

- 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.

- Upon successful completion of the above procedures, REHS will authorize the individual for iodinations.

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 survey meter with a low energy gamma probe must be operable and turned on during the procedure.

A post-experiment wipe test and personal survey must be performed and documented immediately after the iodination procedure. The survey forms will be delivered with the I-125 order. The post-iodination survey form is also available in the Appendices and on the REHS website.

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 $Na_2S_2O_3$) 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 (without H-3) to become familiar with the procedure
- Submit a copy of the procedure to be followed (including vendor) to REHS

PROCEDURE NOTES: Containers should be tightly closed; volatility is enhanced at high pH. The applicant shall include estimated rates of incorporation.

- Submit the room location and the desired hood for review. Upon approval, REHS will enter the approved hood into our database.

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 releases.

- 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.

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-experiment survey must be performed and documented immediately after the procedure.

The researcher may be required to 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, C-14 bicarbonate, 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 RSC requires that all operations involving potentially volatile radioactive materials should be conducted in a properly operating fume hood. The university must tabulate and record 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 $^{35}SO_2$. 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.

B. PROCEDURES WITH BIOHAZARDOUS MATERIALS

If your laboratory generates mixtures of radioactive materials and hazardous biological agents, please be aware of the following:

Laboratories using human cells/tissues, recombinant DNA, creating transgenic plants or animals, or using potentially infectious microorganisms must submit a Protocol for Registration with the Institutional Biosafety Committee. The registration form is located online in the Biosafety Protocol Management System on the REHS website. Please contact the biosafety group for assistance with registration. **The registration of biohazards is separate from the application to use radioactive materials; therefore, researchers should contact the RSO and the Biosafety Officer to discuss their intent to generate mixtures of radioactive materials and biohazardous agents.** Additionally, researchers are required to have biosafety and blood borne pathogens training annually and viral vector training before the first use of these materials. All trainings are available on the REHS website.

The biological component of mixed biological/radioactive wastes must be inactivated or decontaminated prior to removal by REHS. This inactivation step is critical because it greatly reduces the risk of infection for the REHS employees involved in waste handling and processing activities. Please refer to the Waste Disposal section of this guide for guidance regarding the inactivation of biohazards. *Copies of the biohazard forms mentioned in this section can be obtained online via the REHS website or by contacting REHS.*

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 or metal– 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" (see the Appendices for an example)
- A properly completed Radionuclide Disposal Form (yellow waste card) indicating the authoree name, PI number, building name, room number, campus, isotopes, waste type, container volume, the date(s) waste was placed into the container, the radionuclide content of the waste, and the activity present in the containers. These forms should be located near the containers such that it is apparent which container they are associated with. Do not place the form directly on the container to avoid cross contamination.

Waste Acceptance

Dry waste containers should **not** contain the following:

- Free standing liquids
- Lead
- Biohazardous material (BSL-1 or greater, see section entitled Biohazardous Waste)
- Biohazard bags
- Sharps (see section entitled Sharps)
- Metals
- >5% PVC (weight or volume)
- Sealed sources
- RCRA hazardous wastes
- Explosives
- Pyrophoric materials

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

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 **H-3 and C-14 only**
- Waste with half life > 120 days **other than H-3 and C-14** (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 (~4 and 10 liter) polyethylene carboys provided by REHS and stored in a secondary container

- 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"
    - A properly completed Radionuclide Disposal Form (yellow waste card) indicating the authoree name, PI number, building name, room number, campus, isotopes, waste type, container volume, the date(s) waste was placed into the container, the radionuclide content of the waste, and the activity present in the containers. These forms should be located near the containers such that it is apparent which container they are associated with. Do not place the form directly on the container to avoid cross contamination.

Waste Acceptance

- Liquid waste containers should not be overfilled (fill up to the fill line on REHS supplied containers)
- Do not commingle liquid waste with other waste streams (solid, liquid scintillation vial, animal carcasses/tissues)
- Liquid waste containers should be stored in secondary containment
- Do not leave funnels in waste containers (re-cap container when not pouring waste)
- 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
- Disinfect biohazardous material (BSL-1 or greater, see section entitled Biohazardous Waste)

Liquid Waste Segregation Scheme

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

- Waste with half-life $\leq$ 15 days
- Waste with half-life > 15 days and $\leq$ 120 days
- Waste with half-life > 120 days **H-3 and C-14 only**
- Waste with half-life > 120 days **other than H-3 and C-14**

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, or poisonous). Some common procedures performed in the laboratory 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"
  - A properly completed Radionuclide Disposal Form (yellow waste card) indicating the authoree name, PI number, building name, room number, campus, isotopes, waste type, container volume, the date(s) waste was placed into the container, the radionuclide content of the waste, and the activity present in the containers. These forms should be located near the containers such that it is apparent which container they are associated with. Do not place the form directly on the container to avoid cross contamination.

- Note all hazardous and non-hazardous constituents in Section III of the yellow Radionuclide Disposal Form (i.e. water 80%, ethanol 10%, acetic acid 10%).

- 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 (LSVs) can be collected in 30 or 55-gallon drums provided by REHS

- LSV 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)
    - Containers must have a lid or cover

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 of the marking and labeling requirements of a waste container.

Container Labeling

LSV waste containers should be properly labeled with:

- The radiation symbol
- The words "Caution Radioactive Materials"
- A properly completed Radionuclide Disposal Form (yellow waste card) indicating the authoree name, PI number, building name, room number, campus, isotopes, waste type, container volume, the date(s) waste was placed into the container, the radionuclide content of the waste, and the activity present in the containers. These forms should be located near the containers such that it is apparent which container they are associated with. Do not place the form directly on the container to avoid cross contamination.
- The full name of the scintillation fluid must be entered in Section III of the yellow waste card
- A 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 LSV 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 website.
- Liquid scintillation vial waste containing H-3 and C-14 in concentrations greater than 0.05 microcuries/gram may require special consideration (roughly 0.95 mCi/30 gallon drum and 1.75 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
- In Section III, yellow Radionuclide Disposal Forms should be marked with the full name 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 $\leq$ 15 days
- Waste with half life < 15 days and $\leq$ 120 days
- Waste with half-life > 120 days **H-3 and C-14 only**
- Waste with half-life > 120 days **other than H-3 and C-14**

Note: Please attempt to keep the total activity of waste in any liquid scintillation vial drum to less than 1.75 mCi. If you need to exceed this limit, please inform REHS.

E. ANIMAL CARCASSES AND TISSUES

Animal carcasses and tissues 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 and tissues may be stored in freezers in sealed double bags.

Container Labeling

- Animal carcass/tissue waste containers should be properly labeled with:
    - The radiation symbol
    - The words "Caution Radioactive Materials"
    - A properly completed Radionuclide Disposal Form (yellow waste card) indicating the authoree name, PI number, building name, room number, campus, isotopes, waste type, container volume, the date(s) waste was placed into the container, the radionuclide content of the waste, and the activity present in the containers. These forms should be located near the containers such that it is apparent which container they are associated with. Do not place the form directly on the container to avoid cross contamination.

Waste Acceptance

- Do not commingle animal carcass/tissue waste with other waste streams (solids, liquids, and liquid scintillation vials)
- Keep animal carcasses and tissues frozen until removal by REHS personnel
- Prevent sharp edges from puncturing the bags
- Animals contaminated with H-3 and C-14 at a concentration less than 0.05 µCi 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 H-3 and C-14 is less than 0.05 µCi 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.

Animal Carcass/Tissue Segregation Scheme

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

- Waste with half-life < 120 days
- Waste containing only H-3 and/or C-14
- Waste with half life > 120 days other then H-3 and C-14

F. BIOHAZARDOUS WASTE

Radioactive waste that contains biohazardous agents (i.e. Biosafety Level 1 or greater) must be biologically decontaminated prior to REHS pick-up. Some general guidelines are provided below, but many laboratories have unique protocols so these recommendations will not fit every situation. Please contact the RSO or the Biological Safety Officer (BSO) to discuss specific mixed biological/radioactive waste questions.

- Do not autoclave mixed biological/radioactive waste. Radioactive materials are not permitted in campus autoclaves. *If steam sterilization is the only acceptable method for inactivation of your biological agent, please contact the RSO or BSO prior to starting your experiment.*

- Chemical disinfection is the preferred method for inactivating biohazards in both solid and liquid biological/radioactive waste. After inactivating the biohazard, the waste can be placed in radioactive waste containers.

- Consult the Rutgers University Biological Safety Guide for disinfectant options, and choose a disinfectant that is chemically compatible with the waste materials being treated.

**** WARNING ****
Toxic gas can be released by mixing incompatible chemicals such as bleach and ammonia or bleach and iodine.

- Solid items that have been soaking in disinfectant solution should be dried completely before disposal in radioactive waste drums. *Laboratory fume hoods may be used for drying solid items; please notify the RSO if items containing volatile radioisotopes (e.g. I-125 or S-35-methionine) are being dried in your hood.*

- Liquid disinfectant solutions used for biological/radioactive waste should be handled according to the liquid radioactive waste rules

- Write the chemical(s) used for disinfection on the Radionuclide Disposal Forms (yellow waste cards)

- Do not attempt to decontaminate sharps that contain both biohazards and radioactive materials (see section entitled Sharps)

G. SHARPS

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

- Sharps must be collected only in approved sharps containers
- Do not cap syringes before placing in the sharps 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
- 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

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

H. RADIONUCLIDE DISPOSAL FORMS (YELLOW WASTE 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 waste cards.

A yellow Waste Disposal Form 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

PI Name:	Name of the authoree
PI #:	4-digit number assigned to the authoree
Bldg:	Building in which waste is located
Room #:	Room number in which waste is located
Campus:	Campus on which waste is located
Pick Up Date:	To be completed by REHS upon removal

Isotopes:	List all isotopes that are in the container
Waste Type & Container Volume:	Check type of waste, i.e. solid, sharps, liquid aqueous, liquid organic, biological/ carcass or liquid scintillation vials; and size of container, i.e. 30 gal, 55 gal, etc.

Section: II

Date:	Date radionuclides were placed into the container
Isotope:	Radionuclides present in the container
Chemical Name/Form:	Name of the radiolabeled chemical and general chemical family to which the radiolabeled chemical belongs
Activity:	Activity (mCi) contained in each waste entry

Section: III

Total:	Activity totals for each radionuclide entered in Section II
Other Isotopes:	Activity totals for other radionuclides not listed
Liquid/LSV Wastes:	List non-radioactive chemical constituents (in liters) that is in the liquid waste. Calculate the percent volume (i.e. water 80%, ethanol10%, acetic acid 10%). List the type of scintillation cocktail used in this section.
Authoree Signature:	Signature of laboratory employee who is responsible for collection of radioactive waste.

Things to remember while completing Waste Disposal Form (yellow waste cards):

- *Do not perform any correction for decay*
- Enter the activities in millicuries (mCi)
- Sum all of the activity for each isotope in Section III
- 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). The objective is to identify mixed waste, e.g., waste that is both hazardous and radioactive. This is especially important for liquid waste.
- For LSV waste, indicate the full name of the liquid scintillation cocktail
- The forms should be located near the containers such that it is apparent which container they are associated with. Do not place the form directly on the container to avoid cross contamination
- 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.

I. REQUEST FOR RADIOACTIVE WASTE REMOVAL

Removal of radioactive waste takes 5 to 10 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)
- Radionuclides present in waste
- Yellow disposal ticket numbers (located on the bottom right side of the card)
- Number and size of containers

To request a radioactive waste pick-up contact REHS at 848-445-2550 or submit a request for radioactive waste disposal via the REHS website.

XII. SEALED SOURCES & GENERALLY LICENSED DEVICES

Sealed sources are radioactive sources that are encapsulated in some form 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 New Jersey Department of Environmental Protection (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 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
- Liquid scintillation counters
- Static eliminators for balances

A. REQUIREMENTS

Possession of any sealed source requires the appropriate authorization from the Radiation Safety Committee (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 regulations. REHS must be notified whenever a sealed source is purchased, transferred, relocated, or disposed.

B. 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.

C. LABELING REQUIREMENTS

Sealed sources and/or equipment containing sealed sources or GLDs must be properly labeled. See the Appendices for examples. Please notify REHS if you have sealed sources or GLDs that are not properly labeled or if the existing labels have been compromised.

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 on the REHS website. The completed form along with any attachments is submitted to REHS online via our website. 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 procedures (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/or 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 online x-ray training provided by REHS through our website. 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 website). 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 RSC. A management meeting will include the authoree and at least two of the following: the Radiation Safety Officer (RSO) 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 his/her authorization suspended pending a management meeting.

Major non-compliance issues are defined below:

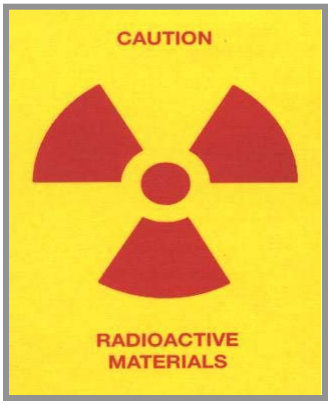
- Disposal or relocation of a radiation-producing machine without notifying REHS
- Failure to comply with REHS requests to repair or add warning lights
- Use of a unit that has not been inspected by REHS
- Failure to report the acquisition of a new or transferred radiation-producing machine
- Use of 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. – unlocked door or keys left in unit)
- Dosimetry is not worn consistently when operating the unit
- Sharing of radiation badges

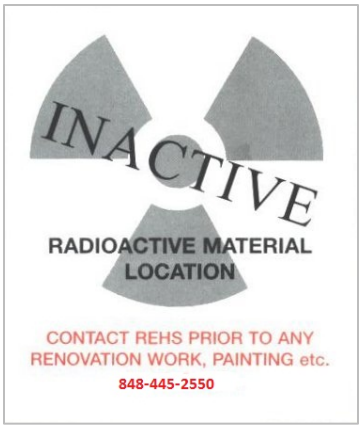
If an authoree or user does not understand any of the policies noted above, please contact REHS for clarification.

Common Postings and Labels



This sign will be posted on doors into radioactive material labs. You may also see it on a hood or equipment that may be contaminated.

This label is found on equipment containing radioactive sources such as liquid scintillation counters, gas chromatographs (with ECD's), etc.



This sticker is posted on all labs that have been deactivated but not fully decommissioned. Any renovation work requires a full decommissioning. Contact REHS prior to painting, removing floor tiles, or removing any fixed equipment.

This signs is posted on lab doors that house radiation producing equipment.

This posting is on all radiation producing equipment.

Rutgers Environmental Health and Safety
Building 4086 · Livingston Campus
Rutgers, The State University of New Jersey
27 Road 1 · Piscataway · New Jersey 08854-8036

Your Radiation Dosimeter – Rules & Limitations

Dear Researcher,

According to the regulations outlined by the New Jersey Department of Environmental Protection (NJDEP), Rutgers University and RWJMS are not required to provide dosimetry (radiation badges) to the vast majority of researchers working with radioactive materials (RAM). That said, we do provide dosimetry to a select population at each university. For example; those who work with high energy beta emitters, select gamma emitters, and some machine sources. You have met our internal criteria for dosimetry, or have chosen to reimburse REHS for dosimetry costs. Enclosed you will find your radiation badges. Your dosimeter is designed to monitor your occupational exposure. Please make sure you understand the rules and limitations (outlined below) of these dosimeters. Dosimeters are exchanged every three months in the beginning of January, April, July and October. Fetal dosimeters are exchanged on the first of every month (or the first business day thereafter). If you have any questions or concerns, please contact Tom Dobbs at 848-445-2550 or tdobbs@aps.rutgers.edu.

Radiation Badge Rules:

- **Do not share your badge.** Your dosimeters are assigned to you and any dose received by the badge will be recorded under your name and kept as a permanent record. If someone in your lab needs a badge, please contact REHS and a spare badge can be issued as needed.
- **Do not deliberately expose them to radiation.** If you think your badges were exposed to radiation inadvertently, please contact REHS for instructions. When you aren't wearing them, keep them where their exposure will be minimal or as close as possible to background radiation levels (such as your desk or an area of the lab where RAM is not used). Do not bring them to the doctor or dentist office since these medical procedures are not "occupational exposures".
- **Wear them appropriately.** Whole body badges measure your deep and shallow doses. They should be worn under your lab coat on the torso between the neck and pelvic area. Ring badges measure extremity doses. They should be worn under your gloves on the finger of the hand which you do most of your radiation work (or the hand nearest to the radiation source).
- **Return badges on time.** Your badges cannot be read if they are not exchanged on time. When you receive your new quarter's badges by campus mail, please return the old badges promptly to REHS.
- **Notify REHS if your badge is lost.** A replacement can be issued anytime during the quarter if your badge is lost or missing. REHS incurs charges for non-returned whole body and ring dosimeters at a cost of $9 and $5 respectively.
- **Do not expose badges to heat.** Do not leave your badge anywhere that it can be exposed to heat such as the window sill or inside a hot car. Exposures recorded on the dosimeter may be erased by excessive heat exposure.

OVER

Rutgers Environmental Health and Safety
Building 4086 · Livingston Campus
Rutgers, The State University of New Jersey
27 Road 1 · Piscataway · New Jersey 08854-8036

Radiation Badge Limitations:

- **Dosimeters are a passive device.** Your dosimeter gives an estimate of the amount of external radiation that you were exposed to. They do not absorb radiation, nor do they help you in any way against the effects of radiation. The results of your dosimeter exposures get reported to REHS several weeks after they are returned to the vendor. Your radiation badge is purely for the purposes of monitoring the amount of radiation you may have been exposed to during your occupational work so that you do not exceed the levels set forth by the NJDEP.
- **They have a minimum detectable level.** Your radiation badge cannot record doses below 10 mrem. If you receive a badge report with "ND" as the reportable dose, this means that the dose received was "non-detectable" (or less than 10 mrem) by the dosimeter. Your badge will not record doses from radioisotopes such as H-3, C-14 or S-35 because the energies of these radionuclides are too low for the dosimeter to record. They work best with higher energy beta emitters such as P-32 or gamma emitters like I-125 or Cr-51.
- **Dosimeters will record any radiation exposure.** The small quantities of radioactive material used in a university setting such as ours, are not usually recorded on our dosimeters. Likewise, if this small quantity of radioactive material is taken into the body, these internal doses will not be recorded. If you suspect that you received an internal radiation dose, contact REHS immediately. Internal exposures can be avoided by carefully planned and executed experimental procedures, including the use of proper personal protective equipment (i.e., lab coat, gloves, safety glasses). The use of a hand-held survey meter such as a Geiger counter can help you avoid any internal exposure by identifying potential areas of contamination before you get a personal exposure. If you have had a medical test such as a nuclear medicine scan or stress test, you should not wear your badge, since these tests usually involve gamma-emitting radionuclides. The radioactive material used for these medical procedures will record a potentially high dose on your dosimeter. These medical tests are not occupational doses. Please contact REHS if you've had one of these procedures. If your badge is stored near radioactive materials or a radiation source, likewise it will record a dose that is not reflective of your occupational exposure.

Your dosimetry report is sent to you once a year via a Form 5. The Form 5 has your dose history for the previous year. If you do not receive a Form 5 (in April of the following year), that means your doses were "ND" (non-detectable). You may request a copy of your quarterly dose report at any time throughout the year. Contact Tom Dobbs at REHS for a copy of this report.

Our goal is to keep your dose ALARA (as low as reasonably achievable). By following these rules and understanding the limitations of your dosimeter, unnecessary radiation doses can be avoided. If you do not meet our badge requirements (see our web site at http://rehs.rutgers.edu), or your radioactive material work has changed and a dosimeter is no longer needed, please send a note along with your badge by campus mail to Tom Dobbs at REHS. Thank you for your anticipated cooperation with the dosimetry program!

REHS
27 Road 1, Bldg 4086
Livingston Campus
Piscataway NJ 08854
Phone 848-445-2550, Fax 732-445-3109
http://rehs.rutgers.edu

Efficiency/MDA Calculations

The University is required to determine the counting efficiency and minimal detectable activity (MDA) of liquid scintillation and gamma counters in order to properly evaluate wipe test results. Monthly laboratory wipe tests must be recorded in units of disintegrations per minute (dpm) as per NRC regulations. To ensure compliance, the following procedures must be performed monthly for, at a minimum, the least efficient isotope that is used in the lab.

A. Determination of Efficiency (E):

a. Use a standard of known activity. Remember that 1 uCi = 2.2×10^6 dpm.

b. Set the gain and discriminator levels (windows) according to the manufacturer's recommendation for the isotope to be counted.

c. Count a blank (background) and the standard for one minute to obtain counts per minute (cpm) for both.

d. Determine the net cpm of the standard by subtracting the background cpm from the standard cpm.

e. Calculate the efficiency (E):
E = net standard cpm/activity of standard in dpm

f. Divide cpm of wipe samples by the efficiency to convert to dpm.

B. Determination of the Minimal Detectable Activity (MDA):

a. Count the blank (background) for one minute

b. Calculate the MDA:

$$\text{MDA (cpm)} = 4.65 \sqrt{\text{background (cpm)}}$$

c. To obtain results in dpm, divide the MDA by the efficiency

d. Record all calculations and results in the lab notebook with the monthly lab wipes. The MDA of the counting instrument should be less than 100 dpm. If not, please notify REHS.

RUTGERS

Rutgers Environmental Health & Safety Dept.
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http://rehs.rutgers.edu/
848-445-2550
Fax: 732-445-3109

FETAL DOSIMETRY PROGRAM

Please fill out this form if you wish to declare your pregnancy. REHS will issue a fetal radiation badge to all pregnant workers who either work with radiation or are concerned because they work in a radioactive materials lab. These badges must be worn at waist level at all times while you are in the controlled area. They will be exchanged on the first of every month (or the first business day thereafter).

Please fill out all of the information below and return this form to REHS via campus mail or fax at 732-445-3109. Information concerning your pregnancy will be kept confidential.

NAME:

_____

Last First Middle

Social Security Number: _____

Date of Birth: _____ E-mail address: _____

Conception Date: _____

Due Date: _____

Home Address: _____

Home Phone: _____ Office Phone: _____

Office Address: _____

Lab Location: _____

Principal Investigator's Name: _____

Signature: _____ Date: _____

PLEASE CAMPUS MAIL OR FAX THIS FORM TO
REHS
BLDG 4086, LIVINGSTON CAMPUS
OR 732-445-3109

Inspection Checklist Explanation

The following document explains the items found on the radiation safety inspection checklist used by REHS. You will receive an emailed copy of your inspection checklist after each radiation safety inspection. Please be aware that items marked with an X for "unsatisfactory" should be corrected immediately. Should you receive a Notice of Violation (NOV) as a result of this inspection, you are required to respond, in writing, within 2 weeks. If you have any questions, please contact the Radiation Safety Officer at 848-445-2550. Most forms and information about radiation safety can be found on the REHS web site.

LAB(S): The labs listed under your authorization that are approved for radioactive material (RAM) work and subject to inspection.

SECURITY: All RAM must be secured. Per the security policy, if there is more than one entrance into or out of the lab, stock material must be locked when it is not in use or under direct surveillance. This can be accomplished by locking the refrigerator or freezer where RAM is stored or storing RAM in a lock box. If the lab only has one entrance/exit, security can be accomplished by locking the door when no one is present and challenging anyone who walks into the lab.

CAUTION SIGN: All doors must be posted with a sign that has the radioactive warning symbol and the words "Caution – Radioactive Materials". Additionally, it lists other hazards the lab may possess and emergency contact information.

2 POSTINGS: REHS will check for the presence of the two required postings in the lab and replace any that are missing, torn, or out of date. These include: 1) The NJDEP Notice to Employees and 2) REHS Radioactive Material Laboratory Safety Rules which lists our NJDEP License Numbers and applicable regulations.

MONTHLY WIPES: All labs must perform a wipe test for contamination in any month that radioisotopes are used. All wipes must be expressed in units of dpm, not cpm. The counter printout sheet (including the date) should be attached to the monthly wipes along with a detailed map of wipe areas. Areas of contamination greater than 100 dpm above background must be cleaned, re-wiped, and documented in the monthly wipe book. *Please note, if your lab does a wipe test in a common lab, you must wipe test that lab every month.*

MDA/EFFICIENCY: Calculations of minimum detectable activity (MDA) and efficiency must be performed and documented monthly. MDA should be less than 100 dpm. An excel spreadsheet that will auto-calculate these numbers can be downloaded from the REHS web site.

DAILY SURVEYS: Both a personal survey and a survey of the work area must be performed with a survey meter *after every use* of radioactive material. These surveys *must be documented a minimum of once per day*. The personal survey should include hands, shoes, clothing etc. A work area survey should include floors, equipment used, and the regular trash container.

SURVEY METER: Survey meters are evaluated to make sure the lab's survey instrument is appropriate for the radioisotopes used (i.e. a pancake GM or NaI probe). REHS will verify the survey meter is in working order and that it responds to a known source of radiation. The lab is responsible for replacing batteries and/or repairing the meter if it is out of order.

WASTE LABELED: All radioactive waste containers must be labeled with a radioactive sticker and must have a yellow waste card associated with them indicating the isotope and approximate activity. A temporary waste container should be labeled with a radioactive sticker and either emptied at the end of the day or have a yellow waste card associated with it. If the lab supplies their own containers, appropriate containers must be utilized.

SECONDARY CONTAINMENT: All liquid radioactive waste containers must be placed in secondary containers capable of containing the entire volume of radioactive liquid in the event of a leak. Proper storage of the container with the lid tightly closed is important. Funnels should not be left in the opening of the waste container.

PROPER SEGREGATION: Radioactive waste must be segregated according to the isotope's half life. See our website for segregation schemes. ***Drain disposal of liquid radioactive waste is prohibited***.

YELLOW WASTE CARD: All radioactive waste containers must have a yellow waste card associated with them, with all sections completely filled out. Section I lists the Authoree information such as name, 4 digit PI number, the building and room number where waste is located. Section II is filled out each time RAM is placed into the container. Section III is filled out for liquid waste. List the ingredients of the liquid waste so that the total volume equals 100%. For LSV waste, the brand name of scintillation cocktail must be filled out in this section. The card must be signed by an authorized radiation worker.

EAT/DRINK/SMOKE/COSMETICS: Eating, drinking, smoking, and applying cosmetics in the labs are prohibited. Food shall not be stored in RAM labs. Evidence of food or drink consumption, such as food wrappers in trash cans, coffee cups, water bottles, etc. will result in a NOV.

RAM PRACTICES: The lab should have dedicated RAM work areas that are clearly labeled. Lab personnel should ensure the safety of visitors and non-rad workers by avoiding contamination using general lab safety practices. Personal protective equipment must be worn when handling RAM. This includes double gloves, buttoned lab coats and safety glasses. Shorts, skirts, and open-toed shoes should not be worn when working in the lab or handling RAM.

Shielding should be used if necessary. Radiation badges, if issued, must be properly worn when working with radioactive materials. Badges must not be lent to others or stored near sources of radiation. After RAM is delivered, the package and inner vial should be checked for contamination (the SOP for package receipt is posted on our website). Before boxes are put in regular trash, any radioactive symbols should be defaced. Lead should be wipe-tested and meter-surveyed for contamination. Please see our web site for lead disposal guidance.

TRAINING: All individuals, who work with radioisotopes, including Authorees, must attend an initial radiation safety class and refresher training every calendar year thereafter. If an Authoree receives a NOV, the Authoree and all radiation workers must attend in-person refresher training. Visit the REHS website to complete the online refresher training or to find dates and register for in-person training sessions.

INVENTORY: Each lab shall keep a written inventory of radioisotopes received and disposed. Inventory log sheets are provided with each RAM package delivered. These forms are pre-printed with the vial information. Blank copies of the inventory-tracking sheet can be found on the REHS web site. Additionally, Inventory Verification Reports (IVRs) are emailed to each Authoree every 6 months for confirmation that receipt and disposal amounts are correct. If the IVR is not returned within 2 weeks, the Authoree could be subject to suspension of RAM delivery.

RADIATION SURVEY: REHS will perform a thorough meter survey of the lab in order to detect contamination. Lab personnel and/or the Authoree will be notified immediately if contamination is found.

Laboratory Clearance Checklist

REHS
27 Road 1, Bldg 4086
Livingston Campus
Piscataway NJ 08854
Phone 848-445-2550, Fax 732-445-3109
http://rehs.rutgers.edu

PI Name: _____ Alt Contact: _____
Email: _____ Alt. Phone: _____
Phone: _____

Building: _____ Lab: _____

	YES	N/A
Notify REHS of Intended Change - check all that apply: ☐ Moving radioactive material research to new lab space ☐ Lab is being vacated/renovated ☐ PI is leaving the University ☐ Other_____	☐	☐
Radioactive Waste Arrange for removal of all radioactive wastes. You can request a radioactive waste pickup at http://rehs.rutgers.edu or by calling 848-445-2550. Carefully review the inventory to ensure all waste is accounted for.	☐	☐
Radioactive Materials - Unsealed Stock radioactive materials can be prepared and transported by REHS upon request. Lab staff are prohibited from transferring or transporting radioactive material without REHS approval.	☐	☐
Radioactive Materials - Sealed Sources Federal (NRC, DOT) and State regulations specifically require REHS to supervise the relocation or transfer of all radiation sources. Notify REHS in advance if a liquid scintillation counter or a gas chromatograph with an electron capture detector needs to be moved, transferred or disposed.	☐	☐
Labeled Equipment All equipment posted "radioactive" must be surveyed • Wipe test results: < than 100 dpm/100 cm^2 **AND** • Meter survey results < or = background measurements • THEN Remove/Deface "radioactive" postings If the wipe test **OR** meter survey results exceed the criteria • Decontaminate and re-survey • Contact REHS if you cannot decontaminate	☐	☐
Freezers Accumulated ice in freezers used to stored H-3 or C-14 should be sampled and analyzed for contamination. Contact REHS for guidance.	☐	☐
Lab Survey Perform a wipe test of the laboratory. Decontaminate and re-survey any area exceeding 100 dpm/100 cm^2. Fax the results to REHS.	☐	☐

NON HAZARDOUS LIQUID SCINTILLATION & FLOW FLUID

Manufacturer	Scintillation Fluid
American Bioanalytical	SafeScint
Amersham	BCS
Amersham	BCS-NA
Beckman	ReadySafe
Fisher Scientific	Scintisafe 30%
Fisher Scientific	Scintisafe Econo 1
Fisher Scientific	Scintisafe Econo 2
Fisher Scientific	Scintisafe Econo F
Fisher Scientific	Scintisafe Gel
Fisher Scientific	Scintisafe Plus 50%
Fisher Scientific	Scintiverse BD
ICN	BetaMax ES
ICN	CytoScint ES
ICN	Ecolume
ICN	Ecolite +
ICN	UniverSol ES
IN/US Systems	In-Flow BD
IN/US Systems	In-Flow ES
Isolab	Solvent-Free
National Diagnostics	Ecoscint
National Diagnostics	Ecoscint A
National Diagnostics	Ecoscint H
National Diagnostics	Ecoscint O
National Diagnostics	Uniscint BD
National Diagnostics	Monoflow 5
Packard (Perkin Elmer)	Ultima Gold
Packard (Perkin Elmer)	Ultima Gold AB
Packard (Perkin Elmer)	Ultima Gold F
Packard (Perkin Elmer)	Ultima Gold LLT
Packard (Perkin Elmer)	Ultima Gold MV
Packard (Perkin Elmer)	Ultima Gold XR
Packard (Perkin Elmer)	Optifluor
Packard (Perkin Elmer)	Optifluor O
Packard (Perkin Elmer)	Emulsifier Safe
Packard (Perkin Elmer)	Ultima Flow AF
Packard (Perkin Elmer)	Ultima Flow AP
Packard (Perkin Elmer)	Ultima Flow M
Packard (Perkin Elmer)	MicroScint 20
Packard (Perkin Elmer)	MicroScint 40
Packard (Perkin Elmer)	MicroScint 0
Packard (Perkin Elmer)	MicroScint PS
Research Product International (RPI)	Bio-Safe II
Research Product International (RPI)	Bio-Safe NA
Research Product International (RPI)	Econo-Safe
Wallac (Perkin Elmer)	Betaplate Scint
Wallac (Perkin Elmer)	Optiphase HiSafe 2
Wallac (Perkin Elmer)	Optiphase HiSafe 3
Wallac (Perkin Elmer)	Optiphase Supermix
Wallac (Perkin Elmer)	Optiphase TriSafe

HAZARDOUS LIQUID SCINTILLATION FLUID

Manufacturer	Scintillation Fluid
Amersham	ACS (Xylene, Methanol)
Amersham	ACS-II (Xylene)
Amersham	PCS (Xylene)
Amersham	OCS (Xylene)
Beckman	Ready Flow III (Pseudocumene)
Beckman	Ready Gel (Pseudocumene, Xylene)
Beckman	Ready Organic (Pseudocumene)
Beckman	Ready Protein (Pseudocumene)
Beckman	Ready Solv HP (Pseudocumene)
Beckman	Ready Value (Pseudocumene)
Fisher Scientific	CytoScint (Pseudocumene)
Fisher Scientific	Scintilene (Xylene)
Fisher Scientific	Scintiverse Bio-HP (Pseudocumene)
Fisher Scientific	Scintiverse E (Xylene)
Fisher Scientific	Scintiverse I (Xylene)
Fisher Scientific	Scintiverse II (Pseudocumene)
Fisher Scientific	Scintiverse LC (Pseudocumene)
IN/US Systems	In-Flow 2
IN/US Systems	In-Flow 3
IN/US Systems	In-Flow TC
National Diagnostics	Betafluor (FP 114°F)
National Diagnostics	Hydrofluor (FP 114°F)
National Diagnostics	Liquiscint (FP 114°F)
National Diagnostics	Ultrafluor (FP 114°F)
Packard (Perkin Elmer)	Aquasol (Xylene)
Packard (Perkin Elmer)	Aquasol-2 (Xylene)
Packard (Perkin Elmer)	Aquassure (Pseudocumene)
Packard (Perkin Elmer)	Atomlight (Pseudocumene)
Packard (Perkin Elmer)	Biofluor (Pseudocumene)
Packard (Perkin Elmer)	Econofluor-2 (Pseudocumene)
Packard (Perkin Elmer)	Filter-Count (Pseudocumene)
Packard (Perkin Elmer)	Flo-Scint 3 (FP 115°F)
Packard (Perkin Elmer)	Hionic-Fluor (Pseudocumene)
Packard (Perkin Elmer)	Insta-Fluor Plus (Pseudocumene)
Packard (Perkin Elmer)	Insta-Gel Plus (FP 114°F)
Packard (Perkin Elmer)	Pico-Fluor 15 (Pseudocumene)
Packard (Perkin Elmer)	Pico-Fluor 40 (Pseudocumene)
Packard (Perkin Elmer)	Pico-Fluor MI (Pseudocumene)
Research Product International (RPI)	3a20 (Toluene)
Research Product International (RPI)	3a70
Research Product International (RPI)	3a70B
Research Product International (RPI)	4a20 (Xylene)
Research Product International (RPI)	Bio-Count
Research Product International (RPI)	Budget-Solve
Research Product International (RPI)	Lefko-Fluor (FP 100°F)
Research Product International (RPI)	Ria-Solve II
Research Product International (RPI)	Safety-Solve
Sigma-Aldrich	Sigma-Fluor (FP 116°F)
Sigma-Aldrich	Sigma-Fluor HP (FP 117°F)
Sigma-Aldrich	Sigma-Fluor Universal (FP 97°F)

Radioactive Materials Lab
Post-Experiment Survey Form

Date	Initials	Personal Survey	Equipment Survey	Bench Survey	Floor Survey	Trash Survey	RAM Secure

RUTGERS ENVIRONMENTAL HEALTH AND SAFETY

27 Road 1
Building 4086 Livingston Campus
Piscataway, NJ 08854
848-445-2550 phone
732-445-3109 fax
http:/rehs.rutgers.edu

Post Iodination Survey Form

REHS Policy requires that a contamination survey be conducted immediately after an iodination is performed. This survey must be performed with wipe tests on bench tops, floors, instruments, and anything else that could have been contaminated during this procedure. Personal surveys of lab coats, shoes, hands, face, etc, can be conducted using a calibrated low energy NaI probe in a **low background** area or use wipes as above.

Wipe Tests

Instrument Model # :		Serial # :	
Background (DPM):		MDA (DPM):	
Efficiency:			
Benchtop (DPM):		Floor (DPM):	
Hood Sash (DPM):		Instruments (DPM):	

Personal Survey

Instrument Model #		Serial #:	
Background (CPM):			
Labcoat / Shoes (CPM):	/	Hands / Face (CPM):	/

- Any wipe test survey result above 100 dpm/100cm² shall be decontaminated and re-surveyed.
- Any personal contamination above background must be reported to REHS immediately 848-445-2550.

By signing below, you are confirming that you have performed the above survey and that any contamination found has been cleaned below applicable limits. When you have your thyroid bioassay, please give this completed form to REHS.

Name (PRINT) _____

Signature and Date _____

RADIONUCLIDE INVENTORY LOG

PI:		**Number of Vials:**	
PI Number:		**Building:**	
Radionuclide:		**Room:**	

	Date	**Activity (uCi)**
Receipt		

USE		**VIAL BALANCE**	**WASTE DISPOSAL (uCi)**					**WASTE TOTAL**
Date	Amount uCi	Amount uCi	Date	Solid	Liquid	LSV	Bio	Amount uCi

R.E.H.S.
848-445-2550 phone ıı 732-445-3109 fax ıı http://rehs.rutgers.edu

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Transfer of Radioactive Material

INSTRUCTIONS:

- Research staff may transfer radioactive material to another authorized permit
- Research staff are **PROHIBITED** from transporting radioactive material by vehicle
- Transfer requests must be submitted to REHS prior to the transfer
- Fax this form to REHS at 732-445-3109 or use the Web version at http://rehs.rutgers.edu/

TRANSFER DATE: _____

RADIONUCLIDE INFORMATION:

Isotope: _____

Activity: _____ mCi

Chemical Form: _____

TRANSFER INFORMATION:

TRANSFER FROM:		**TRANSFER TO:**	
PI Name:		PI Name:	
PI #:		PI #:	
Bldg/Lab:		Bldg/Lab:	
Phone:		Phone:	
Alternate Contact:		Alternate Contact:	

Contact REHS at 848-445-2550 with any questions or problems.

CHARACTERISTICS OF COMMON RADIONUCLIDES

R/N	Emission	Energy Max	Γ	Half-life	Shielding	Instruments	
		(KeV)	(R-cm^2/mCi-hr)			Portable	Fixed
C-14	Beta minus	156	NA	5730 y	None	GM ~ 2%	LSC
H-3	Beta minus	18.6	NA	12.3 y	None	NA	LSC
S-35	Beta minus	167	NA	87.4 d	None	GM ~ 2%	LSC
P-33	Beta minus	249	NA	25.4 d	None	GM ~ 2%	LSC
P-32	Beta minus	1710	NA	14.3 d	Lucite	GM ~ 25%	LSC
Ca-45	Beta minus	256.9	NA	162.7 d	None	GM ~ 2%	LSC
I-125	Gamma X-ray gamma	35 keV (6%) 27 keV (112%) 35 keV (10%)	1.6	60.14 d	Lead	NaI ~ 8%	LSC Gamma
Cr-51	Gamma X-ray gamma	320 keV (10%) 4 keV (67%) 5 keV (20%)	0.18	27.7 d	Lead	GM ~ 2% NaI ~ 2%	LSC Gamma

R/N	Beta Range in Air (cm)	Beta Range in Water (cm)	Dosimetry	ALI Ingestion uCi	ALI Inhalation uCi	Beta Dose rate to skin from 1 uCi over distributed over 1 cm^2
C-14	22	0.03	None	2000	2000	1 Rad/hour
H-3	0.45	0.0006	None	80000	80000	NA
S-35	24	0.03	None	6000	10000	1 Rad/hour
P-33	46	0.06	None	6000	8000	3 Rad/hour
P-32	611	0.79	Yes -mCi quantities	600	900	6 Rad/hour
Ca-45	48	0.06	None	2000	800	3 Rad/hour
I-125	NA	NA	Yes - Iodination	40	60	NA
Cr-51	NA	NA	Yes	40000	50000	NA

Radiation Survey Meters

Radiation meters are used to detect ionizing radiation. All laboratories working with radioactive materials must posses a survey meter with an appropriate detector. The following information is intended to help you make an appropriate purchase.

Radiation Detector Types

Geiger Mueller (GM) – "Pancake"	**Sodium Iodide (NaI)**
• For detection of Beta Emitters • Cannot detect H-3 • Detects radiation via the ionization of a gas contained inside the probe. The ejected electrons are then collected and counted. • Probe has a very thin membrane that is under pressure and easily punctured.	• For detection of Gamma Emitters • Detects radiation via the interaction of ionizing radiation with a scintillating crystal containing Sodium Iodide(NaI). • Laboratory MUST obtain a NaI probe when working with I-125.
Commonly used to detect: C-14, Ca-45, P-33, S-35, P-32	**Commonly used to detect:** Cr-51, I-125

Purchasing a Meter
The Geiger Mueller and NaI probes or detectors can be interchanged and attached to the same survey meter. The Ludlum Model 3 is the most common meter and is a very reliable instrument.

Ludlum Vendors
- Atlantic Nuclear (http://www.atnuke.com)
- Ludlum Instruments (www.ludlums.com)

Other Vendors
- Thermo Electron (Bicron, Eberline), WB Johnson

Once a new meter is received, contact REHS to have an efficiency check performed and added to the REHS database.

Calibrations/Repair
Laboratory meters are checked by REHS annually. REHS checks the efficiency of the meter against a known P-32 and C-14 check source for pancake probes, and an I-129 source for NaI probes. If the meter fails the efficiency check, REHS can try to resolve the problem in-house, but may need to send it back to the appropriate vendor for repair. The lab is expected to cover the cost of any repairs to a meter should the need arise.