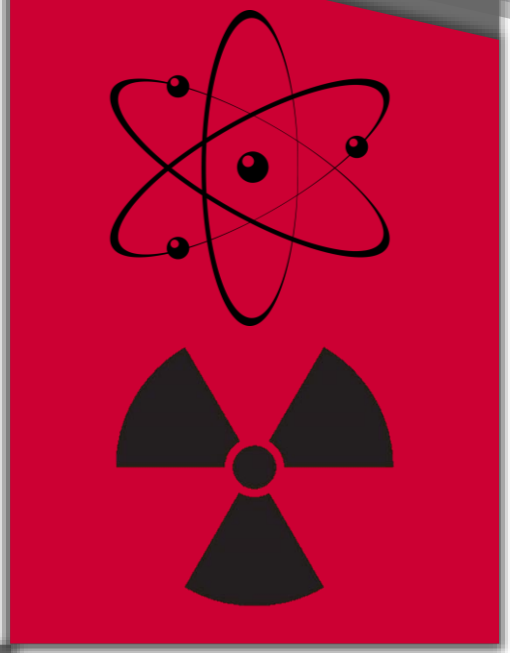
RUTGERS

RADIATION SAFETY GUIDE



Rutgers Environmental Health & Safety

https://ipo.rutgers.edu/rehs/safety/lab/radiation

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RADIATION SAFETY GUIDE

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REHS Radiation Safety Website
https://ipo.rutgers.edu/rehs/safety/lab/radiation

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Many of the documents above are accessible on the REHS Radiation Safety website:

https://ipo.rutgers.edu/rehs/safety/lab/radiation

ABBREVIATIONS	
ALARA	As Low As Reasonably Achievable
BER	Bureau of Environmental Radiation
BSL	Biosafety level
BXC	Bureau of X−ray Compliance
CFR	Code of Federal Regulations *(Examples: Title 10 CFR Part 20, 10 CFR Part 20, 10 CFR 20.1201)*
Ci	Curie
cm	Centimeter
cpm	Counts per minute
DOT	Department of Transportation
dpm	Disintegrations per minute
g	Gram
GLD	Generally licensed device
GLSM	Generally licensed source material
GM or G−M	Geiger−Mueller
HCl	Hydrochloric acid
IACUC	Institutional Animal Care & Use Committee
IVR	Inventory Verification Report
keV	Kiloelectron volt
L	Liter
LD	Lethal dose
LiF	Lithium fluoride
LSC	Liquid scintillation counter
LSV	Liquid scintillation vial
mCi	millicurie
M	Molar
MDA	Minimum detectable activity
mrem	millirem
NaI	Sodium iodide
ND	Non−detectable
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NOV	Notice of Violation
NRC	U.S. Nuclear Regulatory Commission
PA	Particle accelerator
PASO	Particle Accelerator Safety Officer
PI	Principal Investigator (aka, Authoree per this guide)
PO	Purchase order
PPE	Personal protective equipment
PVC	Polyvinyl chloride
QMO	Qualified machine operator
RAM	Radioactive materials
RCRA	Resource Conservation and Recovery Act
REHS	Rutgers Environmental Health & Safety
rem	Roentgen equivalent man
RPE	Radiation Protection Element
RPM	Radiation−producing machine
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
RSP	Radiation Safety Program
SNC	Self−normalization and calibration
SOP	Standard operating procedure
SS	Sealed source
Z	Atomic number
µCi	microcurie

1. INTRODUCTION AND ALARA POLICY STATEMENT

1.1 INTRODUCTION

The radiation safety program (RSP) at Rutgers University ("the University") strives to ensure that all activities and operations involving the use of sources that generate ionizing radiation, specifically radioactive materials (RAM) and radiation−producing machines (RPM), are performed in a way that protects users, faculty/staff, and the public from exposure to unnecessary radiation. For the purposes of this guide, the focus is on **ionizing radiation only (excludes non−ionizing radiation)**, and the term "radiation" may be used interchangeably with "ionizing radiation." Rutgers Environmental Health and Safety (REHS) manages the RSP on all Rutgers campuses (Camden, Newark, New Brunswick) and can field any questions and/or concerns regarding ionizing (and non−ionizing) radiation.

This guide provides the description of the following:

- The organization and responsibilities of all levels of employees pertaining to the RSP.
- Specific regulations, policies, and practices that must be followed when using radiation sources.
- The radiation services that REHS provides to assist the radiation user in their safety program.
- The basics of radiation physics.

Rutgers University appointed a Radiation Safety Committee whose members have established a comprehensive RSP to ensure that all sources of radiation are used in a safe and compliant manner. Specific methods must be developed in every facility where RAM and RPMs are utilized to maintain safety and compliance. **Work with sources of ionizing radiation may not be initiated until written authorization has been received by the Authoree/Principal Investigator that specifically permits that work and confirms all training requirements have been met.** For the purposes of this guide, the terms "Authoree" and "Principal Investigator (PI)" are used interchangeably for a PI who is authorized for RAM or RPM use.

The New Jersey Department of Environmental Protection (NJDEP) regulates the use of RAM and RPM sources, specifically under their Radiation Protection Element (RPE) division. Conversely, 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.

Radioactive Materials

New Jersey is an Agreement State with the U.S. Nuclear Regulatory Commission (NRC). Agreement States have entered into agreements with the NRC that give them the authority to license and inspect radioactive materials used or possessed within their borders. The NJDEP has adopted, by reference, a majority of the NRC's Title 10, Code of Federal Regulations (CFR), Parts 19 and 20 (10 CFR Part 19 and 10 CFR Part 20) under NJ Administrative Code (N.J.A.C.) 7:28. The NRC regulations will be cited throughout this document for ease of reference.

Within the RPE division of the NJDEP, the University's use of radioactive materials is overseen by the Bureau of Environmental Radiation (BER). Rutgers University has a license of broad scope from the NJDEP that permits considerable autonomy pertaining to the use of RAM and management of our RSP.

Radiation−Producing Machines

Within the RPE, the University's use of RPM sources is overseen by the Bureau of X−ray Compliance (BXC). The NJDEP's machine source regulations are located in N.J.A.C. 7:28.

1.2 ALARA POLICY STATEMENT

In practice, radiation doses in the workplace must be maintained **A**s **L**ow **A**s **R**easonably **A**chievable (**ALARA**). 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 resulting from the use of ionizing radiation. Occupational exposure limits are clearly written into regulations and constitute the industry's "standard of care." The University's ALARA program is important and acts as a best management practice.

The University's administration and REHS radiation safety staff will promote ALARA and assist all personnel in practicing ALARA at every available opportunity. All parties, including Authorees/PIs, radiation workers, REHS, and University administration, are responsible for maintaining operations with ALARA in mind. This is achievable, in part, by outlining safety procedures for work involving RAM and RPMs, diligently monitoring the workplace to control the spread of radioactive contamination, and using the three main protective measures in radiation safety (time, distance, shielding). 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, releases, and exposures.

2. PROGRAM MANAGEMENT

2.1 UNIVERSITY EXECUTIVE MANAGEMENT

Executive Management is an individual at the senior management level of the University who retains ultimate responsibility and oversight of the RSP, radioactive materials license ("license"), and associated activities involving radiation. The role of Executive Management at the University is assumed by the Executive Vice President for Academic Affairs. They are also an important member of the Radiation Safety Committee (RSC).

Executive Management is charged with the following duties:

1. Possess knowledge of the RSP and license pertaining to associated program reviews and audit reports.
2. Ensure the University complies with regulatory NJDEP requirements and conditions of the license and safely performs activities involving radiation.
3. Appoint the chairperson, Radiation Safety Officer (RSO), and members of the RSC, as well as define their roles, duties, and responsibilities, and, when possible, attend RSC meetings.
4. Support the RSC and RSO by providing a professional and comfortable atmosphere where people can feel at ease to raise concerns and issues, thereby helping management take proactive steps to address, investigate, and resolve radiation safety issues before they escalate.
5. Delegate responsibilities, when necessary, to other managers who oversee daily operations or certain elements of the RSP.
6. Promote immediate and swift decisions and action on behalf of the University's administration, RSC, and RSO, especially in the event of an emergency.
7. Authorize resources, assets, and funds for the RSP.

2.2 RADIATION SAFETY COMMITTEE

The RSC, the University's administration, and the RSO share responsibility for and implementation of the University's RSP. The RSC is critical for radioactive material licenses of broad scope (e.g., Rutgers' license) and allows the University relative autonomy in making decisions regarding the RSP and its management. A proactive, involved, and informed RSC is essential and aligned with the high standards and integrity established by Rutgers' administration. The RSC is formally appointed by the University's administration (typically, the Executive Vice President for Academic Affairs). RSC membership comprises a member of the administration, the RSO, and faculty representing the major areas of radionuclide use and radiation−producing machines. When practical, Rutgers' various campuses and geographical areas are represented. REHS assists the RSC as necessary.

A quorum of RSC members must be present for the RSC to transact business and consists of the following:

- Chairperson (or their designee)
- Representative of administration (or their designee)
- Radiation Safety Officer
- At least two other faculty members

The RSC is charged with the following duties:

1. Review and approve the policies for the RSP, including the radiation safety guide, to:
    - promote the practice of the ALARA philosophy for all members of the University community and the general public,
    - ensure compliance with all applicable regulations, and
    - promote the environmentally responsible disposal of waste materials.
2. Approve, in advance, all authorized uses of licensed materials, including new procedures, under the RSO's authorization.
3. Oversee and/or approve the audit of the RSP and the radiation safety office annually. This audit shall be thorough and may include sections of the program such as the following:
    - policies and procedures for controlling and maintaining inventory
    - possession limits
    - procurement and transfer of licensed materials
    - emergency response
    - training of users
    - security
    - dosimetry
4. Approve revisions to the radiation safety guide as well as other documents and procedures without prior notification to the NJDEP, as long as these changes do not conflict with specific license conditions or specific NJDEP regulatory requirements.
5. Adjudicate any differences between authorized users and REHS.

The RSC typically meets four (4) times per year. Students, faculty, staff, and members of the general public are encouraged to contact any member of the RSC to discuss issues of concern regarding any aspect of the University's RSP. A listing of the current RSC members is available on the Radiation Safety section of the REHS website here (link to site) or may be obtained by contacting REHS directly.

2.3 RADIATION SAFETY OFFICER (RSO) RESPONSIBILITIES

The responsibilities of the RSO are as follows:

1. Provide consultation for 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 regulations (local, state, and federal), license conditions, and Authoree permit conditions authorized by the RSC.
4. Inspect authorized users and their labs to ensure compliance with the abovementioned criteria.
5. Immediately terminate any activity that is found to be a threat to public health and safety, property, and/or the environment.
6. Provide radiation protection information to personnel pursuant to the NJDEP's regulations under N.J.A.C. 7:28, which references the NRC's 10 CFR Part 19 and 10 CFR Part 20.
7. Periodically meet with and report to the University's administration and the RSC.

The University community is encouraged to contact the RSO or REHS Radiation Safety Group with any questions or concerns regarding the use of ionizing radiation (email: radgroup@ipo.rutgers.edu).

2.4 REHS SERVICES

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

A. LABORATORY INSPECTIONS

REHS staff will regularly perform radiation safety inspections in labs according to the University's RAM license and RPM registration requirements. REHS will perform the following at a minimum:

- Ensure lab entrances are posted with appropriate caution signs
- Provide assistance and advice for radiation–related issues
- RAM lab inspections:
    - Check post–experiment surveys and, if applicable, quarterly wipe testing records
    - Test portable survey instruments for proper operation
    - Ensure RAM waste is properly segregated, labeled with caution signage, and documented on waste disposal form
    - Check to see if RAM inventory is present
    - Survey the RAM lab for radioactive contamination
    - Ensure security measures are being utilized (e.g., locked doors to lab, cabinet, refrigerator/freezer; challenge to visitors by staff; etc.)
    - Assess that RAM practices are being implemented
- RPM lab inspections: refer to *Section 12, Radiation–Producing Machines*

B. RADIATION AND CONTAMINATION CONTROL

During inspections, REHS will conduct surveys with a portable radiation–detecting instrument (if applicable per the radioisotope or RPM) and, if applicable, wipe tests of RAM labs annually.

C. RADIOACTIVE WASTE DISPOSAL AND PICK–UP

✶ DRAIN AND TRASH DISPOSAL OF RADIOACTIVE WASTE IS PROHIBITED ✶

All radioactive waste must be disposed of through REHS. In the lab, radioactive wastes are segregated first by **WASTE TYPE** (e.g., solid, liquid, scintillation vials, animal, etc.) and then by the **HALF–LIFE OF THE RADIOISOTOPE**. All radioactive waste shall be segregated in accordance with the University's guidelines outlined in *Section 9, Radioactive Waste Disposal Procedures*.

D. RADIATION MONITORING OF PERSONNEL

Personnel working with and occupationally exposed to certain sources of radiation (RAM, RPMs) may be required to wear a personal radiation monitoring device called a dosimeter (reference *Section 14, Radiation Monitoring of Personnel* for more information). Authorees/PIs shall ensure that all dosimeters assigned to their laboratory workers are worn and used properly, stored away from radiation when not in use, and returned to REHS on time for dosimeter processing. REHS maintains all radiation exposure records and can provide an individual's occupational radiation exposure report upon request. Individuals who do not require radiation exposure monitoring, as stated in *Section 14*, may request a dosimeter but may be required to pay for the cost of the badge.

E. BIOASSAYS

REHS provides bioassay services for staff who use radioiodine (I–125, I–131). Staff performing radioiodination procedures must obtain a thyroid bioassay within 24 to 72 hours post–iodination. Bioassay requirements associated with other uses of radionuclides or in the event of an internal deposition will be determined by REHS on a case–by–case basis.

F. INSTRUMENT CHECKS

All portable survey instruments are checked for proper operation by REHS during radiation safety inspections. REHS can assist with repairs and coordinate with vendors to arrange repair services.

G. RADIATION SAFETY TRAINING

REHS provides radiation safety training for users of RAM and RPMs. For more detailed information, reference *Section 13, Radiation Safety Trainings*.

H. EMERGENCY RESPONSE

REHS provides emergency response to incidents involving RAM 24 hours/day, 7 days/week.

DURING REHS BUSINESS HOURS (M–F, 8 am – 5 pm)	OUTSIDE OF REHS BUSINESS HOURS
Call REHS directly: 848–445–2550	Call the Rutgers University Police Department: (NOTE: the centralized New Brunswick # can be called for any campus) • New Brunswick campus: 732–932–7211 • Newark campus: 973–353–5111 • Camden campus: 856–225–6111

2.5 ENFORCEMENT POLICY

A. INTRODUCTION & VIOLATIONS

A well−functioning radiation safety program depends on consistent adherence to the policies and procedures established for the safe use of radioactive materials and radiation−producing machines. The NJDEP has two basic premises regarding safety:

1) Consistently following the requirements leads to safety.
2) The only way to ensure consistent compliance and 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 at Rutgers. With this in mind, REHS inspects each authorized laboratory regularly according to the University's license requirements. These inspections are unannounced and generally very thorough. The results of these audits are discussed with the individual(s) in the lab (if present) at the time of the inspection. A final inspection report is sent to the Authoree.

Self−identification and correction of violations by the University are 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. When possible, REHS works proactively with the laboratory community to correct violations and ensure they do not recur. If violations are not corrected or are of sufficient severity, a Notice of Violation (NOV) may be issued to the Authoree.

Class I Violations

Class I violations can potentially 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. The following are examples of **Class I** violations:

- Failure to use the proper personal protective equipment (PPE)
- Failure of Authoree to meet training requirements
- Allowing new employees to work with RPMs or licensed material without proper training
- Eating, drinking, or smoking in the lab (or evidence thereof)
- Failure to perform and/or document wipe tests (if required) and post−experiment surveys
- Significant, undetected radioactive contamination in the laboratory
- Improper radioactive waste disposal and/or loss of licensed material
- Failure to secure licensed material (stock vials of RAM)
- Failure to notify REHS or campus police after a major incident

Class II Violations

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 II** violations:

- Lack of secondary containment for liquid radioactive waste
- Failure to properly segregate radioactive waste
- Failure to properly label radioactive waste
- Failure to maintain an accurate inventory of radioactive materials
- Failure to perform the efficiency, minimum detectable activity (MDA), and/or calculations to convert counts per minute (cpm) to disintegrations per minute (dpm) on wipe tests
- Failure to maintain a functional survey meter
- Storage of radioisotopes (non-stock vial) in unapproved room

For specific information and guidance regarding machine source compliance, refer to *Section 12, Radiation−Producing Machines*.

B. AUTHOREE RESPONSE TO NOV

REHS will communicate violations to the Authoree via REHS' Environmental Health & Safety Assistant (EHSA) software and/or inspection reports. A formal NOV letter may be sent to the Authoree via email or campus mail if the violation warrants it. Authorees must provide a written response to the RSO acknowledging the NOV and detailing corrective actions that will be taken to prevent a recurrence.

The Authoree may contest the NOV if they believe 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 they believe 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.

C. POTENTIAL SANCTIONS

The RSO is responsible for the safe use of ionizing radiation at the University. The RSO, at their discretion, may immediately suspend the permit of an Authoree when warranted. 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 RSC chair, a management meeting may be required for:

- Multiple Class I violations are incurred during a single inspection.
- Two (2) Class I violations issued within a period of twelve (12) months. 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.

- Three (3) Class I NOVs are issued within a period of twelve (12) months. Sanctions are likely to be imposed on the Authoree's permit.
- Multiple and/or repeated Class II violations are incurred within twelve (12) months.

Sanctions could include any or all of the following:

- Required in−service training by REHS.
- Probationary status: They may use licensed material, but inspection frequency will be increased for the term of probation; suspension is likely when a major or repeated NOV is issued during the probationary term.
- Suspension of delivery of licensed materials may be imposed for any of the following:
    - The Authoree fails to attend a management meeting within four (4) weeks of notification
    - During an incident and until the incident has been fully investigated and corrective actions implemented
    - At the discretion of the RSO
- Suspension of the Authoree's permit. The RSC will determine the duration of suspension. The delivery and use of licensed material will be suspended, and RAM may be confiscated with the 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 RAM in their lab will be in compliance with the University's policies and procedures.
- Further Class I violations by the Authoree's lab within six (6) months of any suspension will likely result in an escalated suspension of the authorization.
- The RSO, at their discretion, may immediately suspend an Authoree's permit. Permit suspension would remain in force until an emergency RSC meeting can be convened.
- Permanent revocation of permit.

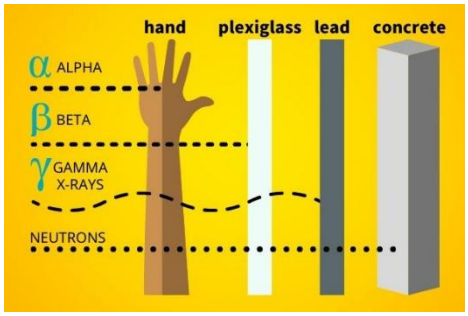
3. PRACTICAL RADIATION PROTECTION

3.1 THE "GOLDEN RULE"

Following the simple "golden rule" will mitigate or eliminate the vast majority of radiological contamination events and significantly minimize their impact. Prior to leaving the laboratory after working with radioactive materials, each individual shall:

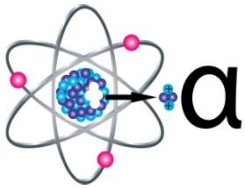
Monitor their person and work area with the appropriate survey instrument and thoroughly wash their hands.

3.2 PREVENTING EXTERNAL EXPOSURE

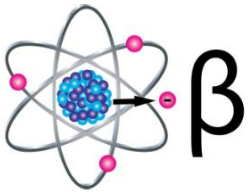


External hazards arise when radiation from a source external to the body has the ability to penetrate the body and deposit energy, causing a "dose." External exposures can be from gamma rays, X−rays, neutrons, and/or beta particles. The exposure is dependent upon both the type and energy of the radiation.

- **Alpha particles**. Alpha particles (α) can travel a few inches in air and rarely penetrate the outer dead layer of skin due to their higher mass and greater electrical charge than beta particles. Therefore, alpha emitters are typically not an external radiation hazard.



- **Beta particles**. Most beta particles (β) 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. Appropriate shielding is needed to reduce the exposure to external radiation.



Important Note: The vast majority of radionuclides utilized in the 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 overexposure, causing the person to exceed the occupational exposure limits. It is very important to survey your person and wash your hands after every use of RAM to prevent inadvertent overexposure.

- **Gamma rays and X−rays**. Gamma rays (γ) and X−rays, as well as neutron radiation, are very penetrating and are of primary importance when evaluating external radiation exposure; therefore, they usually require shielding. The onset of the first observable effects of acute radiation exposure is leukopenia (diminished white blood cell count), which may occur at a dose of approximately 100 rads (=100,000 mrem) of acute whole body radiation exposure. The lethal dose for 50% of the human population (LD_{50}) is about 400 rads of acute whole body exposure, assuming there is no medical intervention.

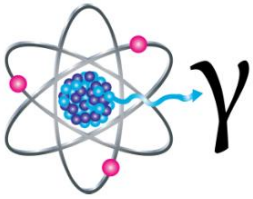


Figure 1: https://www.epa.gov/radiation/radiation-basics

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 using no more radioactive material than is necessary.

External radiation exposure can be reduced using three (3) basic **ALARA** tools: **time, distance, shielding**

TIME

Limiting or reducing the duration of time exposed to radiation will reduce exposure (radiation dose). Radiation dose is directly proportional to exposure time. Below are a few suggestions to help reduce exposure time:

- **Preplanning** - Conduct 'dry runs' of the experiment without using RAM, gather all equipment and supplies needed to perform the experiment prior to the start of work, and conduct the work efficiently.
- **Postings** - Signs posted in RAM work areas will help to keep non−essential personnel away from the radiation field and remind other researchers to avoid the area.

DISTANCE

Increasing the physical distance between the person and the radiation source will reduce exposure. The intensity of a point source of gamma radiation is inversely proportional to the square of the distance per the inverse square law; therefore, greater distance means a lower dose. In a research setting, a small increase in distance can greatly reduce exposure to hands and 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 (4), tripling the distance will reduce the exposure by a factor of nine (9), and so on.

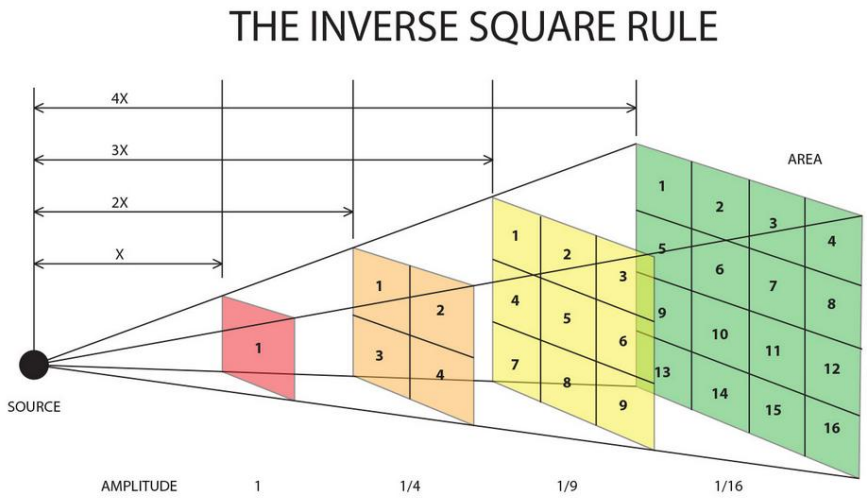


Figure 2: https://kaiserscience.wordpress.com/physics/gravity/law-of-universal-gravitation-and-inverse-square-law/

Do not increase the distance to the point where dexterity or control of the material is compromised. The use of remote handling tools and storing RAM in a remote area are extremely effective methods in reducing radiation exposure when practical.

SHIELDING

Placing an appropriate radiation−absorbing barrier ("shielding") between a radiation source and the person or work area will limit, reduce, or control the exposure. The type and energy of the radiation will determine the type of material, composition, and thickness of shielding to use.

1. **Alpha particles**. Heavy alpha particles travel only very short distances in the air and deposit so much energy over that short distance that they are easy to shield. A person's skin or a piece of paper is sufficient shielding against alpha particles.

2. **Beta particles**. While much less massive than alpha particles, beta particles still have mass and charge. Beta particles are easy to shield.

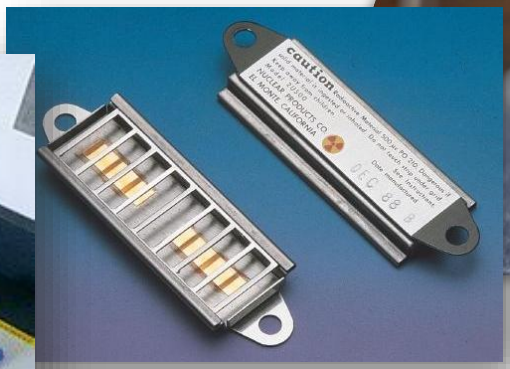
    - Low−density materials with a low atomic number (Z), such as acrylic glass/plexiglass, provide excellent shielding for beta particles. A maximum of 1/2 inch thick sheet of acrylic glass/plexiglass is an effective shield for most beta particles.

    - Thin layers of high−density materials with a high Z, such as lead (e.g., lead foil), must be avoided when shielding high−energy beta emitters (e.g., P−32). This configuration may cause the production of Bremsstrahlung radiation (X−rays) and potentially INCREASE the external hazard of the beta radiation source.

3. **Gamma radiation**. A convenient way to determine the thickness of shielding necessary is to use the concept of the *half value layer* (the amount of shielding that reduces the incident radiation by one−half). This value is commonly advertised with various shielding products. Dense materials with a high Z, such as lead, can absorb more gamma radiation than lighter materials with low Z, such as plexiglass. The most common gamma−emitting isotopes used at the University (e.g., I−125 and Cr−51) are effectively shielded with a few millimeters of lead. For researchers using more energetic gamma−emitting sealed sources, including but not limited to Cs−137, Co−60, and Sr−90, contact REHS for further guidance.

4. **Neutrons**. The properties of neutrons vary depending on their energies; therefore, 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 material via interactions with neutrons. If work with neutron−producing materials/equipment is going to occur, REHS must be contacted prior to the commencement of work.

RADIOACTIVE MATERIALS SECTION



4. RADIOACTIVE MATERIALS

For the purposes of this guide, the terms "Authoree" and "Principal Investigator (PI)" are used interchangeably to describe a PI who is authorized for RAM or RPM use.

Workers at the University utilize radioactive sources in many ways to facilitate research. These sources are initially separated into two broad categories: ***open source*** and ***sealed source***.

- An **open, unsealed radioactive source ("open source")** is a radioactive material that is neither (a) sealed in a capsule to prevent the spread of the RAM nor (b) closely bonded or in a solid form. Open source material is in the form of a liquid, gas, or powder. Examples of the most commonly used open sources at the University include C−14, H−3, I−125, P−32, S−35, and Se−75. Only trained laboratory workers may work with open source material.

  The primary role of the University's radiation safety program is to prevent the spread of contamination and the unintentional ingestion or inhalation of radioactive materials.

- A **sealed radioactive source ("sealed source")** is a radioactive material that is (a) encased in a capsule designed to prevent the source from escaping or being released under normal conditions and (b) closely bonded and in a solid form. (See *Section 10, Sealed Sources*, for more information.)

  Contamination Potential: Low, as sealed sources are designed to prevent dispersal.

  Low Exposure Potential Sources: The majority of sealed sources at the University have very low activity or utilize isotopes that are not energetic enough to be a source of external exposure. Examples include but are not limited to check sources, static eliminators, and electron capture devices.

  High Exposure Potential Sources: Some sealed sources have relatively large activities that may present a significant source of external radiation exposure; therefore, they must be handled carefully. Examples include but are not limited to isotopic−based X−ray fluorescence units, soil moisture/density gauges, and any source used to irradiate samples or cells in the laboratory environment. Only trained laboratory workers may work with high exposure potential sealed sources.

REGULATORY AUTHORITY

Specific License: The University's use of radioactive materials is governed by a *specific license*. This license is issued by the NJDEP's Bureau of Environmental Radiation (BER). It empowers the University to manage the purchasing, use, storage, and disposal of nearly all radioactive materials used to support its teaching and research mission. Under this license, the BER requires Rutgers' Executive Management, the appointed RSC, and the RSO to work together to enforce applicable state regulations and the specific conditions of our license to promote the safe and compliant use of radioactive materials.

General License: A subset of RAM or devices containing radioactive sources that fall outside the scope of the University's specific license mentioned above. These materials (e.g., uranium or thorium-containing compounds) or instruments (e.g., liquid scintillation counters, gas chromatographs with

electron capture devices, etc.) may be purchased by any company/institution without the need for a specific license as mentioned above. Although no specific license is required, those who possess generally licensed materials or instruments must keep proper inventories, utilize the devices as instructed by the manufacturer, maintain appropriate security, and dispose of the materials properly. To the extent practical, REHS maintains an inventory of generally licensed materials and instruments containing generally licensed devices (GLDs). Refer to *Section 10, Sealed Sources (including GLDs)* and *Section 11, Generally Licensed Source Materials,* for more detailed information.

4.1 AUTHORIZATION TO USE RADIOACTIVE MATERIALS

The use of RAM at the University is restricted to personnel authorized by the RSC. Faculty and staff who meet the minimum criteria outlined below shall complete and submit an application package to the RSO.

A. MINIMUM REQUIREMENTS

The minimum criteria are as follows:

- Hold a faculty or staff position of Instructor, Research Associate, or equivalent/higher rank.
- Possess a graduate degree in physical science, life science, engineering, or medicine and have at least six (6) months to one (1) 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 the following:
    - 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
    - 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 licensing determinations on a case−by−case basis.

B. APPLICATION AND APPROVAL

The permit application for RAM use can be found in the "*Applications for Radioactive Material and Radiation−Producing Machine Use*" section on the REHS radiation safety website.

The RSO or their designee will review the application, conduct an interview, and submit their findings to the RSC for consideration. If authorization for RAM use is granted, a RAM permit will be issued by the RSO on behalf of the RSC and will be valid for four (4) years or the timeframe as directed by the RSC. The permit specifies the name of the Authoree, the lab(s) in which RAM may be used, the radionuclide(s) to be used, and the maximum possession quantity of each radionuclide permitted.

C. POLICY ON RAM USE IN HUMANS

The University's NJDEP RAM license prohibits ANY use of RAM in or on humans. No human−use experiments will be approved.

For informational purposes only:

- *Use of RAM in or on a person is authorized under the medical broad scope license of Rutgers Biomedical and Health Sciences (RBHS). For more information on the RBHS medical broad scope license, contact REHS at radgroup@ipo.rutgers.edu or 848-445-2550.*
- *Use of ionizing radiation from a machine source, e.g., computed tomography (CT), X−ray, DEXA scan, etc., must be approved by the Institutional Review Board (link to website).*

D. ANIMAL/IN−VIVO WORK

The University's Institutional Animal Care & Use Committee (IACUC) reviews and approves all protocols involving animals. Animal protocols involving X−ray machines, RAM, and/or irradiators are forwarded to REHS for review. REHS will review each protocol on an individual basis, then 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 animal cages and rooms
- Disposal of deceased 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 RAM permit application
- The radionuclide and/or activity are not currently authorized
- The protocol presents a significant variation on currently accepted research practices

E. ENVIRONMENTAL/FIELD USE OF RADIONUCLIDES

The intentional release of RAM into the environment, i.e., the release of RAM into rivers or streams for research purposes, is strictly prohibited. Such use requires the approval of both the NJDEP and RSC. A detailed copy of the protocol needs to be submitted to REHS several months in advance to obtain the necessary approvals.

F. GAMMA IRRADIATORS

The use of self−shielded irradiators requires pre−approval by REHS, fingerprinting, FBI criminal history check, and special training. If you require a self−shielded irradiator, contact REHS several months in advance for specific requirements and training information.

4.2 AUTHOREE RESPONSIBILITIES

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

1. Attend radiation safety training at the required frequency.
2. Ensure that all radiation workers attend radiation safety training at the required frequency.
3. Ensure that all radiation workers receive in−lab training specific to the procedures and experiments authorized in the permit.
4. Ensure that radioactive materials are used only in approved locations listed on the permit.
5. Inform all non−radiation workers of the potential health hazards of radiation and the established safeguards to ensure a safe workplace.
6. Administer and enforce the radiation safety rules and regulations outlined in this guide and other University policies.
7. Notify the RSO of any prolonged absences or sabbaticals in excess of four (4) consecutive weeks. The RSO and Authoree will jointly determine if the Authoree can maintain oversight of RAM or if a temporary/alternate supervisor is warranted.
8. Ensure (a) laboratory surveys for radioactive contamination are performed and documented at the appropriate frequency and (b) any follow−up action (e.g., decontamination) is documented so that contamination remains below the specified limits.
9. Notify the RSO of fixed RAM contamination (i.e., radioactive contamination that persists despite decontamination efforts).
10. Procure, dispose, and maintain an inventory of all RAM in accordance with University policies.
11. Maintain security of RAM to prevent unauthorized removal in accordance with University policies.
12. Prior approval by REHS is needed when planning the following:
    - Radioiodinations
    - Use of the gaseous form of any radioactive compound
    - Use of all other non−iodine, volatile radioactive compounds
13. Notify the RSO **before** acquiring the following:

Equipment containing sealed radioactive 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

14. **Immediately report spills (major incidents) and/or contamination of laboratory personnel to REHS directly**. After business hours (M−F, 8am−5pm), contact campus police.
15. **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.

4.3 RAM SAFETY TRAINING & DOSIMETRY

For detailed information on training, see *Section 13, Radiation Safety Trainings*.
For detailed information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

4.4 PERMIT RENEWAL AND AMENDMENTS

Radioactive material permits currently do not exceed a four (4) year expiry date from the date of issue (which will be documented on the permit), at which time they must be renewed to ensure uninterrupted use of radionuclides. REHS will contact the Authoree approximately one month before the expiration date with instructions on how to renew their authorization. If RAM permits are not renewed by the expiration date, the RSC and/or RSO may impose sanctions or restrictions on RAM use, including but not limited to sanctions detailed in *Section 2.5, Enforcement Policy*.

The RSC grants amendments to active RAM permits, such as increases in possession limits, additions and 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, the RSO will issue a revised RAM permit on behalf of the RSC.

4.5 PERMIT INACTIVATION, TERMINATION, & REACTIVATION

A. PERMIT INACTIVATION

A permit may be inactivated upon request if an Authoree has stopped using RAM for an extended period. Inactive status relieves the Authoree of routine requirements, such as bi–annual inventory reports, contamination surveys, quarterly use statements, annual radiation safety training, etc.

To request a permit inactivation, complete the *RAM Lab Clearance Checklist* (available on the REHS website and in the *Appendices* of this guide), then email or fax the form to REHS. REHS staff will assist the Authoree with final RAM waste disposal and arrange for an inactivation or full decommissioning survey.

- If most of the contents of the laboratory will remain and the room will not be used for RAM use, REHS will perform an inactivation survey of the laboratory. However, walls and inaccessible areas, such as blocked walls and under/behind refrigerators/other equipment, will not be certified free of radioactive contamination. A gray and white "**INACTIVE**" sticker will be posted on the door indicating that the lab has been surveyed by REHS and found free of radioactive contamination.
- If all of the contents of the laboratory are removed and the room will not be used for RAM use, REHS will perform a full decommissioning survey (aka final status survey) of the laboratory, including walls and inaccessible areas. All RAM caution labels will be removed from caution signs, equipment, refrigerators, freezers, RAM work areas, etc. The absence of RAM caution labels will reflect that the lab has been surveyed by REHS and found free of radioactive contamination.

- If renovation work needs to be performed in a lab (i.e., painting, removing floor tiles, moving fixed equipment, etc.), REHS must be notified at least two (2) weeks prior to the start of renovations so that REHS can decommission the lab, ensuring a safe environment for renovation workers.

B. PERMIT TERMINATION

A permit will be terminated when any of the following applies:

- The Authoree leaves the employment of the University
- Upon request of the Authoree
- As the result of an enforcement action by the RSC

An Authoree may also remove a laboratory from their permit if RAM will no longer be used or stored in that laboratory.

C. PERMIT REACTIVATION

A permit can be reactivated at a later time with minimal effort by performing both of the following:

1. PI submits a written request to reactivate their permit to REHS.
2. The Authoree and their radiation worker(s) either confirm they are current with their radiation safety training or complete the relevant training prior to the anticipated start date.

4.6 LAB POSTING & SIGNAGE REQUIREMENTS: LICENSED RAM

The required signage for a lab where licensed radioactive material (open source stock vials of RAM) is used and stored includes all of the following, which will be discussed in this section:

- Caution sign
- Caution labels
- REHS' ***Radioactive Materials Laboratory Safety Rules*** poster
- NJDEP's ***Notice to Employees***

NOTE: *Posting & Signage Requirements* for other radiation sources: (1) for sealed radioactive sources and generally licensed materials/devices, refer to *Section 10, Sealed Sources (Including GLDs)*; (2) for radiation−producing machines, refer to *Section 12, Radiation−Producing Machines*.

A. CAUTION SIGN

For any lab that contains hazardous materials, a sign with caution/warning alerts ("caution sign") must be posted at every entrance to the lab (on the door or immediately adjacent wall). The Authoree/PI is responsible for ensuring a caution sign is present at all entrances to their lab(s) and requesting a new or replacement sign if it is absent/compromised or when labels are incorrect or missing. To submit a caution sign request to REHS, the Authoree/PI/lab manager can complete and submit the form at this website:

http://halflife.rutgers.edu/forms/cautionsign.php

When REHS receives the request, they will create a caution sign with all applicable caution labels affixed. REHS is responsible for posting the proper caution sign at entrances to laboratories, equipment rooms, and other work areas where hazardous materials, including radioactive materials, may be used or stored.

The following information should be listed on the caution sign at each active RAM lab entrance:

- Caution labels for all hazards, including a radiation hazard label containing the following:
  - Radiation warning "trefoil" symbol
  - The words "**CAUTION RADIOACTIVE MATERIALS**"

- The primary person to contact in the event of an emergency. Acceptable primary contacts include the Authoree/PI, lab manager, room supervisor, or lab technician.
- A secondary contact person if the primary contact is not available in the event of an emergency.
- The contact's name, campus address (building and room number), and campus phone number should be listed and updated to maintain current information.

B. CAUTION LABELS

Caution labels provide warnings and information about hazards, such as RAM, and can be in the form of stickers or tape (both are available in various sizes) that can be affixed to various places. The following areas, items, and equipment should be labeled with a visible caution label that contains both the radiation warning "trefoil" symbol and the words "**CAUTION RADIOACTIVE MATERIALS**":

- Areas where RAM is used and handled: bench tops, biosafety/fume hoods, shelves, etc.
- Items that store or transport RAM: refrigerators, freezers, containers, storage areas, waste containers, etc.
- Laboratory equipment that is used with RAM, contains RAM, or is contaminated with RAM: flasks, beakers, centrifuges, pipettes, shielding, etc.

(See the *Appendices* of this guide for a listing of radiation caution labels.)

C. OTHER REQUIRED POSTINGS

REHS is responsible for posting the following in every lab where RAM is stored or handled:

- REHS' ***Radioactive Materials Laboratory Safety Rules*** poster
- NJDEP's ***Notice to Employees*** (describing standards for protection against radiation)

The Authoree/PI is responsible for ensuring these postings are present in their lab(s) and requesting a new or replacement posting if any are absent or compromised.

While not a frequent occurrence, should a laboratory need to utilize large quantities of energetic beta or gamma emitters, contact REHS for further guidance and instructions. These uses could result in local dose rates greater than 5 millirem (mrem) per hour, which requires additional postings.

4.7 RADIATION WORKER RESPONSIBILITIES

A radiation worker is authorized to work with RAM under the auspices of a RAM permit, and is responsible for the following:

- Complete the relevant radiation safety training at the required frequency.
- Adhere to regulations, license conditions, and guidelines pertaining to the safe handling of RAM.
- Report any abnormal occurrence, such as a major incident (e.g., RAM spill) or significant contamination, to the Authoree and REHS immediately.
- Gain approval of the Authoree and REHS before making changes to experimental protocols.
- Ensure the security policy for RAM is enforced at all times.

4.8 POLICY FOR MINORS WORKING IN AUTHORIZED RAM LABS

Minors (persons under 18 years of age), including students, full–time employees, part–time employees, and both paid and unpaid 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 near RAM or equipment that produces ionizing radiation must not receive a "whole body" dose in excess of 500 mrem per year.

New Jersey labor laws prohibit minors from working directly with radioactive material. However, if the use of RAM is required as part of an educational degree program, a request for accommodation to use RAM can be submitted to REHS for consideration. For more information, policies, and responsibilities pertaining to workers who are minors, refer to the section titled ***Volunteers and Minors in the Laboratory*** on the REHS website: https://ipo.rutgers.edu/rehs/minors–lab

✶ Authorees/PIs/Managers must notify REHS if they have or intend to have a minor working in their laboratory that contains any radioactive materials and/or radiation–producing machines ✶

If the minor will work in a RAM lab but not work directly with RAM, REHS will perform the following:

- Review the work to be performed by the minor
- Evaluate the laboratory environment to determine any potential for the minor to receive a radiation dose even though they will not work directly with the RAM/equipment
- Arrange for radiation safety training for the minor

(For information regarding minors working in X–ray labs, see *Section 12, Radiation–Producing Machines*.)

4.9 PREVENTING INTERNAL EXPOSURE TO RAM

Prevention of internal exposure to RAM is very important, and work practices shall be designed to reduce the risk of internal exposure. All forms of RAM can inadvertently be deposited in the body through any of the following four (4) routes of entry:

- Inhalation
- Ingestion
- Injection
- Skin absorption

Doses resulting from internal depositions may be acute or chronic. The actual dose delivered due to a unit uptake will vary widely between the radionuclides and the individual. The radionuclide's physical (and biological) half–life will greatly affect the total dose delivered.

If you suspect that you have had an internal exposure, IMMEDIATELY CONTACT REHS (during normal business hours) or 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 the following:

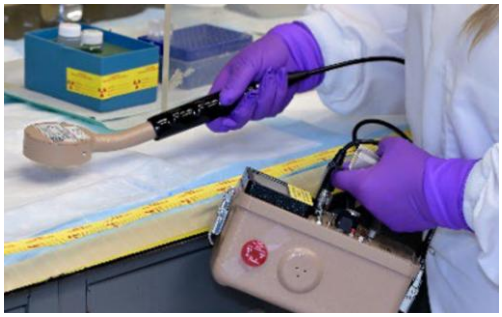
- Inform REHS whenever you propose to work with volatile sources of licensed RAM.
- Work with volatile RAM in an approved, properly functioning fume hood or filtered glove box.
- Utilize proper PPE (e.g., lab coat, long pants, closed–toe shoes, double gloves, etc.) when handling open, unsealed sources of licensed RAM.
- Carefully handle and dispose of contaminated sharps (dispose only into sharps containers that are properly labeled).
- Thoroughly survey your person and work area after working with licensed RAM. Depending on the radioisotope, use an appropriate survey meter (exclude meter use for H-3, Fe-55, Ni-63) and/or perform wipe testing.
- Washing your hands prior to leaving the laboratory.

4.10 REQUIRED SURVEYS IN RAM LABS

Whenever open, unsealed sources of RAM (e.g., powders, salts, or liquid solutions contained in vials, test tubes, flasks, etc.) are handled, it is possible to contaminate laboratory bench tops, floors, equipment, door/cabinet knobs & pulls, and yourself and/or others (e.g., hands, skin, clothes, etc.). Every lab where RAM is handled must be surveyed for radioactive contamination regularly, which is essential to:

- Prevent the spread of contamination to equipment and personnel/visitors
- Reduce external exposures
- Prevent inadvertent internal depositions of RAM

The two survey methods used to detect radioactive contamination in a laboratory include:

Meter Survey	Wipe Testing
	

A. METER SURVEY

A survey meter is a portable, hand−held, electronic instrument that detects ionizing radiation during a direct radiation field survey. The choice of a survey instrument (which contains the unit's electronics) and probe/detector must align with the type of RAM being used.

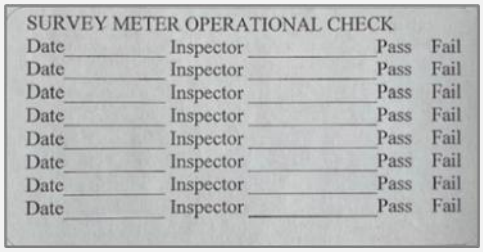
	Mid to high energy beta emitters	Low energy gamma emitters
Isotopes such as:	C−14, Cl−36, Cr−51, F−18, P−32, P−33, S−35, Se−75, etc.	I−125, Cr−51, Fe−55, etc.
Example of Appropriate Survey Instrument	**Ludlum Model 3** 	**Ludlum Model 3** 
Example of Appropriate Probe/Detector	**Geiger−Mueller (G−M) pancake detector or equivalent**  **NOTE**: End−window G−Ms are discouraged, as they lack the detection sensitivity, as seen with the pancake probe.	**Sodium iodide (NaI) scintillator probe** 

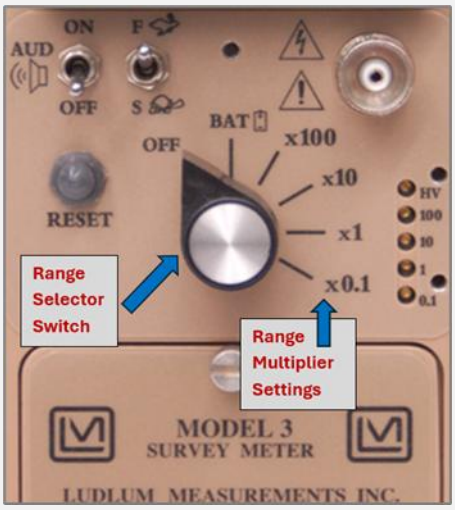
Important: H−3, Fe−55, and Ni−63 are such low energy beta emitters that they cannot be effectively detected by hand−held radiation detection instruments (e.g., survey meter). Wipe tests are the only available method to detect contamination of these isotopes (see *Contamination Survey with Wipe Testing* section for more information).

Contact REHS if assistance is needed to purchase a meter, obtain a loaner meter from the REHS stock, or when a meter is not working properly.

HOW TO PERFORM A METER SURVEY

When using portable survey instruments, the proper techniques must be employed to ensure accurate results. Guidelines for proper survey instrument use are as follows.

Use the Correct Detector or Probe	• Mid to high energy beta emitters = G−M pancake probe (ideal for C-14, Cl-36, Cr-51, F-18, P-32, P-33, S-35, Se-75) • Gamma emitters = sodium iodide probe (ideal for I-125, Cr-51, Fe-55)	
Check the REHS Operational Check Sticker	On the *Survey Meter Operational Check* sticker affixed to the meter, check that the operational check of the meter by REHS for the most recent date passed. If it failed, do not use that meter.	
Perform Battery Check	Turn the range selector switch to **BAT**. Ensure the needle on the meter face is striking within the **BAT TEST** range (see picture). If the battery check fails, replace the batteries. (For the Ludlum Model 3, replace with 2 "D" batteries.)	
Audio and Detection Response Settings	• Check that the **AUDIO/AUD** toggle switch is set to **ON** when using the instrument's audible response while conducting surveys. The audible response is faster than the meter scale indication. Listen for any increases in "clicks" above background levels. • Check that the **F-S** toggle switch is set to "**F**" (fast) for a "real-time" detection response (most common setting). When a slower survey is warranted (i.e., a slow, stable meter movement), set the switch to "**S**" for slow.	

Scale Sensitivity Setting	Turn the range selector switch to the proper range multiplier ("scale") setting on the instrument for conducting the survey. **Always start with the lowest multiplier scale available, e.g., x0.1 or x1**. Select higher range multiplier scales as necessary to obtain maximum meter readings if contamination is detected that exceeds the selected range. **Measurements visualized on the meter face will be multiplied by the range multiplier scale selected**.	
Operational Check of Meter	Ensure the instrument is operable by holding the detector/probe near a known source of radiation. Examples include a check source, source vial, or any radiation source the user knows will promote a meter response.	
Background Radiation Measurement	Obtain a background radiation measurement in an area where RAM is not used or stored. When recording measurements, counts per minute (cpm) should be used. Make a note of the background radiation reading.	
Survey Techniques	• Hold the detector (window side with screen) approximately 1 centimeter (cm) above the object or surface to be surveyed. If the detector is too far away, you may not detect the contamination or may underestimate the level of contamination. If the detector touches the surface(s) being monitored, the detector may become contaminated. • **Do not cover the probe with plastic wrap or Parafilm** since any covers will act as a shield and decrease the detection capability of the meter. • Only read in CPM, even if the meter has mR/hr listed on the meter face. • Survey slowly - the detector's sensitivity is inversely proportional to increasing survey speed. As a rule of thumb, survey 1–2 inches/second. • If contamination is found, maintain the position of the probe over the area for about 10 seconds and note the cpm value displayed on the meter face. Then, multiply the cpm number by the selected scale number (aka range multiplier, e.g., x0.1, x1, x10, etc.) to determine the measurement. **Example**: If the cpm value displayed is 3K (=3,000) cpm, and the selected range multiplier scale is set at *x10*, then the correct value for the radiation being detected is 3,000 cpm x 10 = **30,000 cpm**.	

B. CONTAMINATION SURVEY WITH WIPE TESTING

Wipe tests are a type of survey that allows you to detect removable (loose) radioactive contamination on surfaces. Radioactivity that can be removed from a surface by a cotton swab or piece of filter paper indicates that the radioactivity can cause contamination of hands, skin, shoes, clothes, devices/equipment, and other items if contact is made. Knowing if a surface has radioactive contamination allows lab workers to take action to decontaminate the affected area. The analysis and counting of wipes shall be performed in a liquid scintillation counter (LSC) or gamma counter.

Figure 3: https://www.revvity.com/

Figure 4: https://www.beckmancoulter.com/

Figure 5: https://www.hidex.com/

- The Authoree and/or laboratory workers will need to perform wipe tests for any RAM spills.
- At the discretion of the RSO and/or Authoree, a laboratory may be required to reinstate performing wipe tests or perform them on a more frequent interval based on the risk posed by a specific radionuclide, the level of activity utilized, consistent contamination issues, or past evidence of undetected contamination in the lab.
- REHS has designed an Excel spreadsheet that can be used by the lab as an invaluable tool for the researcher when performing the appropriate calculations for, and the proper documentation of, their wipe test surveys. The *Wipe Test Form (Excel)* is available on the REHS radiation safety website.

For users of LOW ENERGY BETA EMITTERS (e.g., H–3, Fe–55, Ni–63):

- Recommendation: Perform wipe tests after each experiment that uses low energy beta emitters.
- **Quarterly wipe testing**
    - When H–3, Fe–55, or Ni–63 are used within a calendar quarter (e.g., January–March, etc.), wipe testing must be performed at the end of that quarter to ensure the absence of RAM contamination. Quarterly wipe tests must be documented in the lab's wipe test logbook.
- *"Quarterly Use"* statements (formerly, monthly *"No Use"* statements) are required if the lab has an inventory of H–3, Fe–55, or Ni–63 to document use or no use.

  The *Quarterly RAM Use Statement Form* is located on the REHS website here: https://ipo.rutgers.edu/rehs/quarterly-ram-use-statement-form
- Users of low energy beta emitters must have access to a functional LSC to run wipe test samples.

For users of GAMMA EMITTERS and MID TO HIGH ENERGY BETA EMITTERS (e.g., P−32, S−35, C−14, Se−75, Cr−51, I−125):

As of July 1, 2023, due to a decision made by REHS and the RSC, radionuclides that are detectable by hand−held radiation detection instruments no longer require the following:

- Periodic (monthly or quarterly) wipe testing
- *"Quarterly Use"* statements (formerly, monthly *"No Use"* statements)

Post−experiment contamination surveys (also known as "daily surveys") with a survey meter are still required after each experiment.

Laboratory Map

For labs requiring periodic wipe testing, a map detailing the lab's wipe test locations must be created, including areas where RAM is used, stored, and wasted/disposed of.

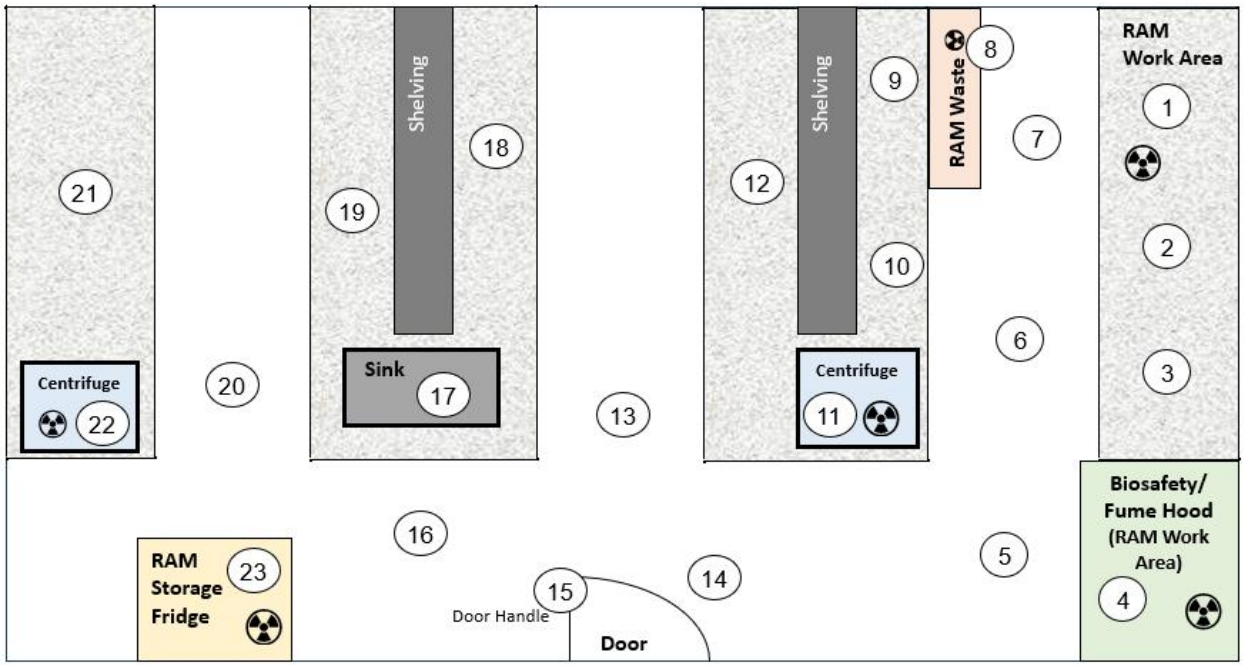


Figure 6: Example of a map detailing a lab's wipe test locations

WIPE TESTING PROCESS

NOTE: When contamination involving either gamma or mid to high energy beta emitters is suspected, first survey bench tops, fume hoods, and other work areas with a survey meter and appropriate detector probe. If any areas are above background levels, decontamination procedures might be necessary prior to taking wipe samples.

SUPPLIES

Figure 7: https://www.revvity.com

- Cotton tipped applicators/swabs or filter paper disks
- Scintillation vials
- Scintillation cocktail (*Approved Liquid Scintillation Cocktail* list located on REHS website here: https://ipo.rutgers.edu/rehs/safe-liquids)
- PPE: disposable gloves
- LSC (including appropriate standard(s) and a background or blank vial)

STEPS

1) Identify and draw a lab wipe test map of the areas to be surveyed, if not already created.
2) Using cotton tipped applicators/swabs or filter paper disks, perform a series of wipes on working surfaces (e.g., benchtop, floor, equipment, etc.) where RAM contamination may be expected to exist. The wipe technique should involve rubbing the surface with moderate pressure using an "S" wipe pattern over a surface area of about 100 square centimeters (cm^2) (4 inches X 4 inches; equivalent to the size of a US dollar bill) at a time.
3) Place the wipe sample swab or filter paper disk into a clean scintillation vial.
4) Add an approved scintillation cocktail to the vial to cover the entire swab tip or paper disk.
5) Apply a cap snuggly to the vial, then gently swirl or invert the vial a few times.
6) Label the vial for the wipe location that references the location number on the room's wipe test map.
7) Repeat steps ***b*** through ***f*** for each area/item to be wiped.
8) In the LSC, count the sample wipes along with the appropriate standard and a background or blank vial for one (1) minute to calculate the LSC efficiency, net disintegrations per minute, and MDA (these calculations are summarized in the *Appendices*. **An open window (0–2000 channel) must be used** – however, multiple windows can be used, and additional channel settings can be counted. Reference the user manual or contact REHS for details about open window/channel settings.

   Contact REHS if an LSC is inoperable or not accessible. Records of wipe surveys, raw data, and efficiency/MDA calculations of the LSC are to be maintained on file in the laboratory and will be reviewed by REHS during laboratory inspections.

STANDARDS FOR LSC

The LSC efficiency for:

- H−3 = 55−65%
- C−14 = 92−95%

At least 1 standard must be run per wipe test cycle in the LSC.

- If H−3 or Ni−63 is used, then run the **H−3 standard**.
- If other radionuclides are used, then run the **C−14 standard**.
- **Exceptions**: radionuclides in use with an efficiency less than that of H−3 within the LSC (most common examples are Cr−51, Fe−55, Mn−54, Se−75) will require the lab to either make or order a standard for that radionuclide.

9) Review the LSC results printout and perform the MDA and counter efficiency calculations. LSCs provide results in cpm, which must be converted to dpm using a conversion equation. To easily calculate the MDA and counter efficiency, REHS advises using their *Wipe Test Form (Excel)* spreadsheet that contains pre−loaded conversion equations and functions (form available on the REHS radiation safety website).

Figure 8: https://www.revvity.com/

- Amount of removable contamination shall be recorded in the following unit of measure: **dpm/100 cm^2**
- Action limit for decontamination = 100 dpm/100 cm^2 above background.

If any sample area has a wipe test result value greater than 100 dpm/100 cm^2 above background (for tritium users, the values would be elevated in the H−3 channel), then investigate the area for radioactive contamination. The area must be decontaminated with an appropriate foaming cleanser, re−wiped, and re−counted until the area is below the action limit to confirm the removal of contamination. All wipe test sample results (initial and re−wiped) should be retained in the wipe test logbook.

If lab personnel cannot fully decontaminate the area of elevated activity, contact REHS for assistance. For radioisotopes that are detectable by a survey meter, ensure the area is surveyed after cleaning the removable radioactive contamination. Fixed radioactive contamination is always possible.

If high wipe test values are still observed and the area has been either sufficiently decontaminated or deemed free of contamination, the high counts could be due to other causes, such as static electricity or chemiluminescence. Perform the following steps to determine if the high counts are due to either or both of those causes:

a) Step 1: Perform a static test by wiping the vials with an antistatic sheet (e.g., Bounce® dryer sheet), then re−count the samples in the LSC.

b) Step 2: If step 1 does not reduce the values, then store the wipe test vials in a dark drawer overnight, then re−count the samples in the LSC the next day.

c) If the above steps did not reduce the values, contact REHS for further guidance.

C. REQUIRED SURVEY TIMEFRAMES

1. POST−EXPERIMENT SURVEYS ("DAILY SURVEYS")

Post−experiment surveys must be performed after every use of unsealed RAM. When multiple experiments using RAM occur on the same day, workers will perform multiple surveys during that day, however, documentation is only required once that day on the *Post−Experiment Survey Form*.

- **For gamma and mid to high energy beta emitters**, post−experiment surveys should be performed with a portable survey meter/instrument if available; otherwise, wipe tests can be performed. Prior to starting the experiment, ensure the meter is:
    - Working by performing a battery test
    - Not beyond the calibration due date

  (See *Direct Radiation Field Survey with Portable Survey Instruments* section for more details on meter selection, use, etc.)

- **For H−3, Fe−55, Ni−63, and other low energy beta emitters**, post−experiment wipe tests are recommended to be performed since these radioisotopes are not detectable with a portable survey meter.

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 RAM experiment, such as centrifuges, vortexes, refrigerators, gel dryers, etc.
- **Bench Survey**: all benchtops that were used during the experiment and drawer handles
- **Floor Survey**: the floor in front of all areas used during the experiment
- **Trash Survey**: survey the non−radioactive trash to ensure no RAM was accidentally disposed of in the regular trash container

Daily surveys must be documented at least once each day that RAM is used on the *Post-Experiment Survey* form. The surveyor shall document the date, their initials, and the areas surveyed. A copy of this form is available on the REHS radiation safety website and in the *Appendices* of this guide.

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, then documented properly and noted on the *Post−Experiment Survey* form. Additionally, wipe tests should be conducted to verify that all contamination has been removed. Areas such as the inside of labeled waste containers or mild contamination inside labeled centrifuges need not be decontaminated. If lab personnel cannot fully decontaminate the area of elevated activity or are unsure of how to proceed, contact REHS for assistance.

2. IMMEDIATE POST-IODINATION SURVEYS

Immediate surveys of the person and work area must be performed following iodination procedures and documented on the *Post−Iodination Survey* form provided to the lab upon delivery of radioactive iodine (the form is also available on the REHS radiation safety website and in the *Appendices* of this guide). The completed survey form must be returned to REHS when the iodinator obtains their thyroid bioassay. Refer to *Section 8, Special Procedures,* 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.

4.11 GENERAL LAB SAFETY PRACTICES

- All personnel must be current with radiation safety 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. When practical, PPE should be removed before leaving the laboratory. Gloves are strongly discouraged from being worn outside the laboratory environment.
- Dosimeters shall be worn properly by the assigned individual and exchanged in a timely manner.
- Dosimeters that are not being used shall be stored in a location that represents the background radiation for the area (e.g., badge board, office desk drawer, etc.).
- Eating, drinking, smoking/vaping, and applying cosmetics are prohibited in the laboratory. Food, beverages, and utensils shall not be stored or disposed of in the laboratory.
- Use appropriate shielding and other dose reduction techniques to minimize radiation exposure in the laboratory.
- Use absorbent pads or work in a spill tray. Clearly mark RAM work areas with "Caution Radioactive Material" labels/stickers.
- All operations involving potentially volatile radioactive materials shall be conducted in a properly operating fume hood.
- Each Authoree must have an operable portable radiation survey instrument available that is 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 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 (see *Section 9, Radioactive Waste Disposal Procedures*). **DRAIN DISPOSAL OF RADIOACTIVE WASTE IS STRICTLY PROHIBITED.**
- Provide for the security of all radioactive materials in accordance with University policies.
- Wash hands thoroughly and survey yourself and your work area after working with RAM.
- Report all accidents involving radioactive materials to:
    - REHS during business hours (M−F, 8am−5pm)
    - Rutgers University Police Department outside of REHS business hours

5. ORDERING, RECEIPT, AND TRANSFER OF LICENSED RAM

5.1 ORDERING RADIOACTIVE MATERIALS

REHS must be notified in advance of ALL incoming deliveries and acquisitions of RAM (e.g., purchases, gifts, samples from collaborative institutions, etc.). RAM purchases from a vendor (e.g., Revvity, MP Biomedicals, Millipore Sigma, etc.) are conducted through the appropriate purchasing system at Rutgers.

1. Regular purchase orders (PO) must be created to purchase all RAM. *Quick* ("Q") orders will not be accepted for a RAM order.
2. When entering POs, ensure that (a) the Authoree's name is on the order and (b) the PO is coded correctly as a "*radioactive order*" in the purchasing system.
3. The University's NJDEP license number (**460345**), Authoree's name, and Authoree's 4–digit authorization/PI number must be indicated in the description section.
4. The following REHS address must be used as the destination for ALL shipments of RAM to Rutgers:

   Rutgers Environmental Health & Safety (REHS)
   74 Street 1603
   Piscataway, NJ 08854

5. Notify REHS in advance of each RAM order via any of the following options:
   - REHS website (preferred): https://halflife.rutgers.edu/forms/isotopeorder.php
   - Email: radgroup@ipo.rutgers.edu
   - Phone: 848–445–2550

   All of the following information must be provided to REHS, as this information reduces processing time and ensures the material will be delivered on the day it is received:

   a. Authoree name and 4–digit Authoree/PI number
   b. Purchase order number
   c. Date ordered
   d. Building name and room number
   e. Vendor
   f. Radionuclide
   g. Quantity

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

5.2 RECEIPT OF PACKAGES CONTAINING RADIOACTIVE MATERIALS

ALL packages containing RAM must be delivered to REHS. The major RAM vendors (e.g., Revvity, MP Biomedicals, Millipore Sigma, etc.) are instructed to ship all RAM orders to only the REHS address above. Radioactive material packages are recorded and surveyed for external contamination and radiation levels upon receipt by REHS staff. REHS verifies that the Authoree is authorized for the radionuclide and checks the possession limits. Authorees exceeding their possession limits will be denied receipt of the RAM package until the discrepancy is resolved or arrangements are made for a radioactive waste pickup.

The RAM packages are delivered directly to the lab on the day of receipt or in accordance with the Authoree's instructions. Upon delivery of the RAM package to the lab, REHS must obtain a signature from an authorized user in order to release the package to the lab. Each lab should keep a copy of the delivery form for at least one (1) year. REHS also provides an inventory log sheet to the lab for their maintenance of RAM inventory data. This form lists the radionuclide activity 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 RAM PACKAGE**
    - Only lab personnel who have successfully completed radiation safety training are qualified to receive and open RAM packages.
    - Inspect the vendor's packing slip/list.
    - Verify that the package is intended for the correct PI's laboratory.
    - Verify that 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 is not opened immediately.
2. **REMOVING THE "PIG" CONTAINER AND STOCK VIAL**
    - Wear PPE: gloves (appropriate to the radionuclide/chemicals), lab coat, & safety glasses.
    - Use shielding if necessary for the radionuclide (e.g., Lucite or plexiglass shielding for high energy beta emitters; lead shielding for gamma emitters).
    - Verify the label on the primary vial displays the correct radionuclide, activity, and volume.
    - Wipe testing of "pig" containers and stock vials
        - Wipe test both of the following:
            a) **"Pig" container** (holds and protects RAM vial for shipment and storage)

gray pig = made of lead

blue pig = made of plastic (no lead)

            b) **RAM stock vial**
        - For low energy beta emitters (e.g., H−3, Fe−55, Ni−63), wipes must be counted in a liquid scintillation counter.
        - For radionuclides detectable by a survey meter (excluding H−3, Fe−55, Ni−63), hold the wipe to the meter with the appropriate detector to assess activity level:
            - G−M pancake probe for mid to high energy beta emitters
            - Sodium iodide (NaI) probe for gamma emitters

- If the wipe results (via meter survey or LSC) of the pig container and vial are:
  - Consistent with the background radiation level, there is no evidence of radioactive contamination. Place the RAM in a secure area.
  - Above the background radiation level, contact REHS for assistance.

3. **DISPOSAL OF BOXES AND PACKING MATERIALS**

   a. Verify that the box is completely empty.

   b. Survey the packaging material for contamination (survey meter with the appropriate detector for radioisotopes detectable with a meter; wipe testing for H−3, Fe−55, Ni−63.)
      - If the survey results are above background, STOP HERE. Dispose of the packaging material as is (do not compress or alter the packaging in any way) into the lab's solid radioactive waste container. Contact REHS to inform them that the packaging material had radioactive contamination and obtain further instructions.
      - If the survey results are consistent with background, continue with box and packaging material disposal processing to the next step (c).

   c. Deface any radioactivity caution/warning symbols or appearance of the words "radioactive material" before disposing of them in the regular trash.

5.3 TRANSFER OF RADIOACTIVE MATERIALS

1. **TRANSFER WITHIN THE UNIVERSITY**

   Authorees who wish to transfer RAM to another Authoree within the University must submit a *Transfer of Radioactive Material* form (available on the REHS radiation safety website and in the *Appendices* of this guide) to REHS prior to transferring RAM. Once approved, REHS will update each Authoree's inventory based on the form data. Options for transferring the material include:

   - Authoree and/or lab staff walk the material to the receiving laboratory. A sealed secondary container must be used to transport the material safely.
   - Request REHS radiation safety staff members transfer the material.
   - All transfers requiring transportation involving a motor vehicle (e.g., cross−campus or between campuses) must be performed by REHS staff.

   Due to Department of Transportation (DOT) regulations, all research faculty and staff are prohibited from (1) transporting RAM by any motor vehicle and (2) offering RAM for transport to a commercial or private carrier.

2. **TRANSFER OUTSIDE THE UNIVERSITY**

   All RAM shipments must conform to DOT and NJDEP regulations. Therefore, all shipments of RAM leaving Rutgers University must be approved, packaged, and shipped by REHS, which will also obtain the authorization of the receiving institution and a copy of the receiving institution's RAM license. Research personnel must prepare an inner package according to REHS' guidance, which may include dividing the samples into two or more packages. REHS will pick up the inner package,

complete the outer packaging and shipping papers, and arrange for delivery. The Authoree is responsible for shipping costs (e.g., FedEx shipping charges) associated with the RAM shipment.

Contact REHS at least two (2) days in advance of the intended transfer to ensure the necessary arrangements can be made. REHS requires the following information:

- Radionuclide(s)
- Activity
- Chemical form
- Any additional hazards
- Temperature requirements (e.g., dry ice, reusable cooler packs, room temp)
- Recipient/transferee ("Ship To") information (e.g., name, address, telephone number)

5.4 INVENTORY VERIFICATION

As an NJDEP licensee, Rutgers University must maintain an accurate inventory of all present radioactive materials. Therefore, each Authoree is required to maintain an adequate inventory log and be knowledgeable of the various forms and quantities of RAM 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) that lists all transactions that took place during the previous 6 months and includes all of the following:

- Delivery of radioactive materials
- Removal of radioactive waste
- Transfer of radioactive material to another Authoree within the University
- Transfer of radioactive material to another institution
- Correction of data entry errors

Authorees must review the IVR, compare it to their current inventory, and submit it to REHS. If errors or incorrect data exist, the appropriate corrections and a brief explanation should be documented on the report so that REHS can make the necessary changes. Failure to submit the IVR in a timely manner will result in suspension of RAM delivery. Delivery will be reinstated upon receipt of a signed copy of the IVR.

Some helpful tips for maintaining an accurate inventory include:

- Keep ALL documents associated with an incoming RAM 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 radionuclides, the vendors usually ship more than the ordered activity. REHS assigns the ***actual activity received*** to the Authoree's inventory, not the lesser amount that was ordered. Personnel must keep track of the total activity received.
- Activity located in the lab's RAM waste containers ***remains on the Authoree's inventory***. Activity of RAM waste is deducted from the inventory after it is physically removed from the lab.
- Radioactive decay that occurs while the radionuclide is in the possession of the Authoree is not considered. Do not account for decay on the IVR.

6. SECURITY OF LICENSED MATERIALS

The NJDEP requires that RAM be secured against unauthorized removal. All RAM must be secured or under the immediate control and surveillance of the authorized user. Each Authoree is responsible for maintaining the security of RAM 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. Generally, a lockbox or locked refrigerator/freezer will be required to secure source vials if a laboratory has ingress and egress from anywhere other than the main entrance.

Strategies for maintaining the security of RAM include the following:

- Locking labs where RAM is used or stored when staff is absent, especially for labs with only one main entrance.
- Locking RAM storage areas (e.g., cabinets, refrigerators, freezers, or utilizing a lockbox).
- Maintaining surveillance of RAM while it is in use.
- Challenging unauthorized entry into the lab by questioning all visitors about the nature and purpose of their visit.

7. INCIDENTS AND EMERGENCIES

7.1 WHAT IS AN INCIDENT OR EMERGENCY?

Unintended incidents may occur during the use of RAM, such as spills, contamination of the worker or work area, or accidental release into the air. When an incident occurs, the worker must first assess whether it is a **minor** or **major** incident (see the *Emergency Procedures for Radiation Incidents* table on the next page that lists the factors for making this determination).

When in doubt, contact REHS for guidance. **There are no repercussions for timely reporting of an incident or requesting assistance, regardless of the circumstances or actions leading up to the incident**.

Figure 9: Source-Adobe Stock Image

7.2 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 or 911 to report an incident, the following information should be provided:

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

EMERGENCY PROCEDURES FOR RADIATION INCIDENTS

MINOR Incident **(If all of the following are true)**	**MAJOR Incident** **(Any of the following conditions)**
• **< 100 microcurie (µCi) of radioactive material (RAM)** • No personal contamination • Localized contamination • No spread of RAM outside licensed areas • Proper tools & knowledge available for clean up	• **100 µCi of RAM** • Any amount of personal contamination (i.e., skin, clothing, and PPE 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 for MINOR Incident	**Laboratory Guidelines for MAJOR Incident**
• **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 the skin with the appropriate meter & detector • Wash skin gently with warm soap and water • Warn other personnel • Notify REHS and Authoree • If after hours, call campus police • Try to prevent the spread of contamination • Await the arrival of REHS

EMERGENCY CONTACTS

DURING REHS BUSINESS HOURS (M–F, 8am–5pm)	Call REHS directly: 848–445–2550
OUTSIDE OF REHS BUSINESS HOURS	Call the Rutgers University Police Department (RUPD) and say to the police dispatcher that you have “an incident involving radioactive materials.” (NOTE: the New Brunswick # can be called for any campus) • New Brunswick campus: 732–932–7211 • Newark campus: 973–353–5111 • Camden campus: 856–225–6111

7.3 BASIC RESPONSE PROCEDURES

Contamination is when RAM is in an unwanted or unplanned location, such as on floors, work areas, equipment, people/clothing, or areas outside the authorized laboratory. Fortunately, most radioactive contamination is easy to remove and clean to background levels in a reasonable amount of time and at an affordable cost.

Every lab should have appropriate RAM spill cleanup supplies on hand. Concentrated liquid decontamination agents are available from most scientific suppliers. Foaming bathroom or kitchen cleaners are effective at a much lower cost.

7.4 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. Contamination of removable gloves (e.g., nitrile, latex, etc.) is not considered personal contamination; however, if activity is evident on the skin of the hands after removing gloves, then this is considered a personal contamination event.

It is essential to document and retain a record of the following:

- Amount of contamination found. Document the maximum survey meter reading in counts per minute (cpm) AND the meter's scale setting (e.g., x0.1, x1, x10, x100).
- Approximate area of skin contaminated – mark the outside circumference with a pen or marker.
- Date/time the contamination was discovered and the time the contamination was removed.
- Serial number of the survey meter used; set the meter aside for REHS inspection.

STEPS FOR SKIN DECONTAMINATION – IMMEDIATE DISCOVERY

1. Personnel who have identified contamination should begin decontamination immediately.
    - **Skin**: Wash affected areas of skin with only lukewarm water and mild soap repeatedly until REHS staff arrive, the contamination has been removed, or further washing will abrade the skin. 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 on the skin. When drying an area of the skin that has been decontaminated by washing, only pat it dry (do not rub the skin).
    - **Eyes**: Irrigate/flush eyes at an eye wash station for 15–30 minutes until REHS staff arrive, the contamination has been removed, or further flushing will significantly irritate the eyes.
2. Decontamination will be performed in a manner to avoid spreading it to other parts of the body. All cleaning should be performed from the periphery (outside) of the contaminated area towards the center of that area.
3. Survey the skin and eyes every few minutes to assess for the presence or absence of radioactivity.

4. Personnel assisting in decontamination will use necessary precautions and PPE (e.g., gloves, safety glasses/goggles, and lab coats) to prevent the spread of contamination to their person or surrounding area.
5. If the affected area is not effectively decontaminated, do not try alternate decontamination methods. REHS will determine other methods and actions upon their arrival.

STEPS FOR SKIN DECONTAMINATION – DELAYED DISCOVERY

When skin contamination is discovered but there is uncertainty of when and where it originated, first follow the above steps for immediate skin decontamination. Then, contact REHS for further assistance.

8. SPECIAL PROCEDURES

8.1 USE OF VOLATILE MATERIALS

Specific chemical reactions may generate radioactive gases, thereby increasing the risk of inhalation by the user. Special procedures, such as iodinations using I−125 and reduction experiments using tritiated sodium borohydride ($NaB[^3H]_4$), require prior approval from the RSC due to their increased potential for volatilization.

1. IODINATION PROCEDURES

Iodine−125 (I−125) is widely used to prepare tracers for immunoassays and other procedures for detecting and localizing biological samples. I−125 exhibits specific physical, chemical, and biological properties requiring 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, of which about 30% of that deposition will be taken up by the thyroid gland and retained with an estimated effective half−life of 40 days. Unintended intake of I−125 by means of ingestion exceeding 40 µCi or inhalation exceeding 60 µCi would cause an individual to reach the NJDEP's annual occupational radiation 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, the iodinator is responsible for:

- Obtaining a baseline thyroid bioassay from REHS prior to use.
- Applying for whole body and extremity radiation dosimeters.
- Performing dry runs of the experiment (without radioactivity) first to become familiar with the procedure.

- Submitting a copy of the iodination procedure to be followed to REHS.

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

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

  PROCEDURE NOTES: The fume hood must be vented directly to the roof using dedicated ducting that is not ganged with other ductwork. The fume hood shall have a demonstrated face velocity of 80–100 linear feet per minute at a sash height of no less than 18 inches (face velocity shall be determined annually and documented on the labels affixed to the hood). This data will be used to calculate any effluent releases.

- Arranging for REHS to observe the final dry run of the mock iodination using mock versions of buffers, solutions, equipment, etc., that are to be used in the "real" procedure.

- Upon successful completion of the above processes and procedures, REHS will authorize the individual(s) for iodinations.

WORKPLACE PREPARATION AND REQUIREMENTS

- The following PPE is needed:
  - Double set of disposable gloves (sleeve guards recommended); particular attention should be paid to glove selection, their chemical compatibility with the reagents involved, and the breakthrough time of compatible reagents.
  - Safety glasses or goggles
  - Lab coat (disposable is recommended)
- All iodination procedures must be performed in an approved fume hood.
- A survey meter with an operable low energy gamma probe must be turned on during the iodination procedure.
- A post–experiment wipe test and personal survey must be performed and documented immediately following the iodination procedure. A post–iodination survey form will be delivered with the I–125 order (also available on the REHS radiation safety website and in the *Appendices* of this guide).
- **The iodinator must obtain a thyroid bioassay 24–72 hours post–iodination from REHS. The researcher is responsible for scheduling this bioassay for the iodinator. Failure to have the bioassay performed in the appropriate time frame will result in an NOV**.
- Radioactive waste containers may require shielding (REHS can help determine shielding requirements during the approval process).

- Consider making an Iodo−Mix solution available for application to spills, rinsing equipment, and adding to the liquid waste containers to help stabilize the radioiodine and reduce volatilization.

IODO−MIX (0.1M NaI, 0.1M NaOH, 0.1M $Na_2S_2O_3$)	
RADIONUCLIDE	**INGREDIENTS**
I−125	25 grams (g) Sodium Thiosulfate 2 g Sodium Iodide in l liter (L) of 0.1 molar (M) Sodium Hydroxide

2. REDUCTION PROCEDURES

Tritiated sodium borohydride ($NaB[^3H]_4$) is employed in the labeling of carbohydrates. It also has applications in the following:

- Organic synthesis to reduce aldehydes, ketones, acid chlorides, and anhydrides.
- Industrial application to reduce carbonyls, peroxides, and metal ions.
- Purifying and removing organic chemicals' color, odor, and oxidation precursors.

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, the applicant is responsible for:

- Submitting a baseline urine sample to REHS prior to $NaB[^3H]_4$ use (if more than 100 mCi of H−3 will be utilized).
- Performing dry runs of the experiment (without H−3) first to become familiar with the procedure.
- Submitting 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.

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

  PROCEDURE NOTES: The fume hood must be vented directly to the roof using dedicated ducting that is not ganged with other ductwork. The fume hood shall have a demonstrated face velocity of 80−100 linear feet per minute at a sash height of no less than 18 inches (face velocity shall be determined annually and documented on the stickers affixed to each hood). This data will be used to calculate effluent releases.

- Arranging for REHS to observe the final dry run of the mock reduction using mock versions of solutions, equipment, etc., that are to be used in the "real" procedure.
- Upon successful completion of the above procedures, REHS will authorize the individual(s) for this procedure.

WORKPLACE PREPARATION AND REQUIREMENTS

- The following PPE is needed:
    - Double set of disposable gloves (sleeve guards recommended); particular attention should be paid to glove selection, their chemical compatibility with the reagents involved, and the breakthrough time of compatible reagents.
    - Safety glasses or goggles
    - Lab coat (disposable is recommended)
- All procedures must be performed in an approved fume hood. A closed system may be employed depending on activity.
- A post−experiment wipe test must be performed and documented immediately after the procedure.
- The researcher may be required to submit a urine sample 12−72 hours post−reduction procedure to REHS.

3. OTHER COMMON USES INVOLVING POTENTIALLY VOLATILE SOURCES

Experiments with commonly authorized radionuclides (e.g., 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 know this potential, plan the experiments accordingly, and contact REHS for guidance.

The RSC requires that all operations involving potentially volatile RAM be conducted in a properly operating fume hood. The University must tabulate and record the quantity of radioactive emissions released to the environment annually. If procedures can potentially release airborne RAM, it is crucial that REHS account 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, which is available from the vendor.

8.2 PROCEDURES WITH BIOLOGICAL MATERIALS

If your lab generates mixtures of RAM and biological agents, please be aware of the following:

- Labs using human cells/tissues/bodily fluids, recombinant DNA, pathogens/infectious agents, biological toxins, or creating transgenic plants or animals must submit a *Protocol for Registration* to the Institutional Biosafety Committee. The protocol registration form is available online at https://myrehs.rutgers.edu in the *Biosafety Protocols Management System* section. For registration assistance, contact the REHS Biosafety group (email: biosafety@rutgers.edu).

  The registration of biohazards is separate from the application to use RAM; therefore, researchers should contact the RSO and the REHS Biosafety group to discuss their intent to generate mixtures of RAM and biohazardous agents.

  Additionally, personnel and students working in a research laboratory are required to complete REHS' *Laboratory Safety/Biosafety/Bloodborne Pathogens (BBP)* training upon hire and annually thereafter, as well as complete online viral vector training, as applicable, before the first use of these materials. Registration for all training classes is available in the *Training Calendar* at https://myrehs.rutgers.edu.

- The biological component of mixed biohazard/radioactive wastes must be inactivated and decontaminated prior to RAM waste 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. For guidance regarding the inactivation of biohazards, refer to *Section 9, Radioactive Waste Disposal Procedures*.

  For more information on the REHS Biosafety Program, please refer to the following website: https://ipo.rutgers.edu/rehs/biosafety-program

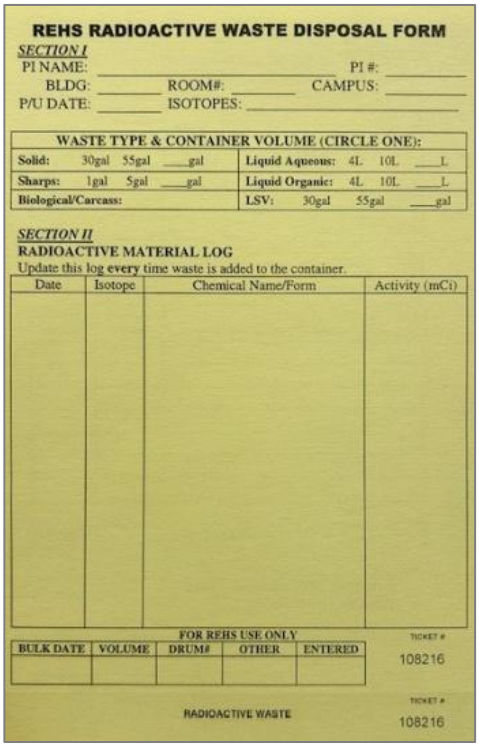
9. RADIOACTIVE WASTE DISPOSAL PROCEDURES

Radioactive waste is defined as any waste that is contaminated with or contains radioactive material. REHS provides radioactive waste management, removal, and disposal services, as described in this section.

9.1 RADIOACTIVE WASTE DISPOSAL FORMS ("YELLOW WASTE CARDS")

The terms of the University's license require detailed records of receipt, use, and disposal of RAM since all RAM must be accounted for. Always compute the radionuclide balance in each waste container in millicuries (mCi) or microcuries (µCi). The yellow waste card's default unit is pre-printed in *mCi,* as seen in the images at left and center below. If your waste contains *µCi* quantities, cross out *mCi* and write *µCi* at the top of the columns used to document activity (see image at right below). A clear distinction between *mCi* and *µCi* is essential to ensure that the correct activities are removed from the lab's inventory.

A *Radioactive Waste Disposal Form* ("yellow waste card") shall accompany each radioactive waste container. The yellow waste cards should be documented when RAM waste is placed into the container. Don't wait until the container is full of waste to complete the card.



REHS RADIOACTIVE WASTE DISPOSAL FORM

SECTION I

PI NAME: _____ PI #: _____

BLDG: _____ ROOM#: _____ CAMPUS: _____

P/U DATE: _____ ISOTOPES: _____

WASTE TYPE & CONTAINER VOLUME (CIRCLE ONE):	
Solid: 30gal 55gal ___gal	Liquid Aqueous: 4L 10L ___L
Sharps: 1gal 5gal ___gal	Liquid Organic: 4L 10L ___L
Biological/Carcass:	LSV: 30gal 55gal ___gal

SECTION II

RADIOACTIVE MATERIAL LOG

Update this log every time waste is added to the container.

Date	Isotope	Chemical Name/Form	Activity (mCi)

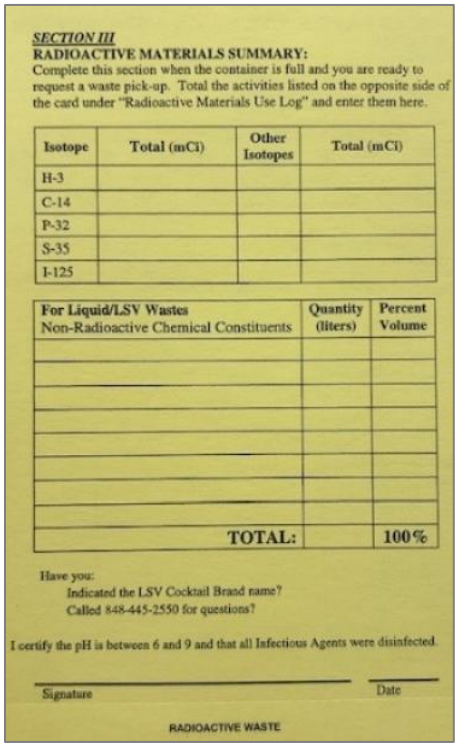
FOR REHS USE ONLY

BULK DATE	VOLUME	DRUM#	OTHER	ENTERED

TICKET # 108216

RADIOACTIVE WASTE

TICKET # 108216



SECTION III

RADIOACTIVE MATERIALS SUMMARY:

Complete this section when the container is full and you are ready to request a waste pick-up. Total the activities listed on the opposite side of the card under "Radioactive Materials Use Log" and enter them here.

Isotope	Total (mCi)	Other Isotopes	Total (mCi)
H-3			
C-14			
P-32			
S-35			
I-125			

For Liquid/LSV Wastes Non-Radioactive Chemical Constituents	Quantity (liters)	Percent Volume
TOTAL:		100%

Have you:

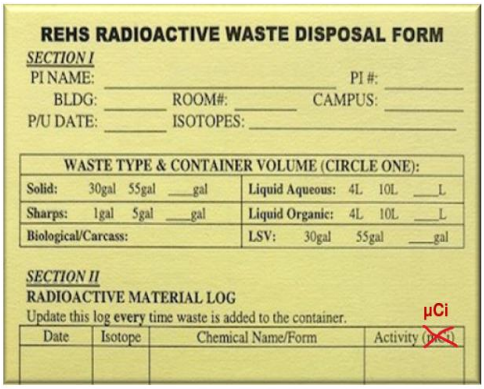
Indicated the LSV Cocktail Brand name?

Called 848-445-2550 for questions?

I certify the pH is between 6 and 9 and that all Infectious Agents were disinfected.

Signature _____ Date _____

RADIOACTIVE WASTE



REHS RADIOACTIVE WASTE DISPOSAL FORM

SECTION I

PI NAME: _____ PI #: _____

BLDG: _____ ROOM#: _____ CAMPUS: _____

P/U DATE: _____ ISOTOPES: _____

WASTE TYPE & CONTAINER VOLUME (CIRCLE ONE):	
Solid: 30gal 55gal ___gal	Liquid Aqueous: 4L 10L ___L
Sharps: 1gal 5gal ___gal	Liquid Organic: 4L 10L ___L
Biological/Carcass:	LSV: 30gal 55gal ___gal

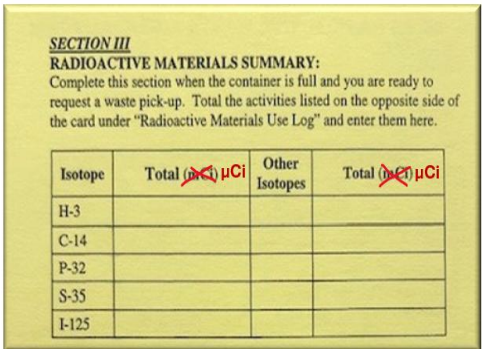
SECTION II

RADIOACTIVE MATERIAL LOG

Update this log every time waste is added to the container.

µCi

Date	Isotope	Chemical Name/Form	Activity ~~(mCi)~~



SECTION III

RADIOACTIVE MATERIALS SUMMARY:

Complete this section when the container is full and you are ready to request a waste pick-up. Total the activities listed on the opposite side of the card under "Radioactive Materials Use Log" and enter them here.

Isotope	Total ~~(mCi)~~ µCi	Other Isotopes	Total ~~(mCi)~~ µCi
H-3			
C-14			
P-32			
S-35			
I-125			

If multiple Authorees share a RAM waste container, a yellow waste card must be completed and displayed near the waste container for each Authoree/laboratory.

For example: If Dr. Jones and Dr. Cooper share a solid RAM waste container, then 2 yellow waste cards are needed (one for Dr. Jones and one for Dr. Cooper).

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 where 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:	Select each of the following: 1. **Type of waste** (e.g., solid, sharps, liquid aqueous, liquid organic, biological/carcass, or liquid scintillation vials) 2. **Size of container** (e.g., 30−gal, 55−gal, 4 L, 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 or µCi) contained in each waste entry (remain consistent)

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 all non−radioactive chemical constituents (in liters) in the liquid waste. Calculate the percent volume (i.e., water 80%, ethanol 10%, acetic acid 10%). List the type of scintillation cocktail used in this section.
Authoree Signature:	Signature of any radiation worker in the lab who is responsible for collecting radioactive waste (signature of Authoree/PI is not required).

Things to remember when completing *Radioactive Waste Disposal Form*:

- **Do not perform any correction for decay.**
- Enter the activities in mCi or µCi, and remain consistent with one or the other.
- Enter the sum of all the activities for every isotope in Section III.
- Clearly state the chemical name and form of the radiolabeled chemical (Section II).
- List each chemical component, including its percentage (Section III), other than radiolabeled chemicals recorded in Section II. The objective is to identify mixed waste (waste that is both hazardous and radioactive). This is especially important for liquid waste.
- For liquid scintillation vial (LSV) waste, indicate the full name of the liquid scintillation cocktail.

- The yellow waste cards should be located near the containers so that it is apparent which container they are associated with. Do not place the cards directly on the container to avoid cross−contamination of RAM onto the card.
- Remember to sign the yellow waste cards.
- Unless yellow waste cards are properly completed and signed, REHS personnel will not pick up radioactive waste.

9.2 SOLID (DRY) RAM WASTE

Solid (dry) RAM waste consists of contaminated laboratory waste that does not contain liquids, such as paper, gloves, plastic containers, absorbent pads, pipette tips, etc.

CONTAINER TYPES

Solid RAM waste can be collected in any of the following:

- Drums (30− or 55−gallon) and 5−gallon buckets that have two (2) liners (all provided by REHS)
- Waste containers can also be purchased by the lab, provided ALL of the following criteria are met:
    - Must be rigid (e.g., plastic, metal; bags alone are not adequate due to puncture potential)
    - Must have two (2) liners (REHS can provide plastic liners)
    - Must have a lid or cover

CONTAINER LABELING

Solid RAM waste containers shall be appropriately labeled with ALL of the following:

- Radiation warning "trefoil" symbol
- The words "**CAUTION RADIOACTIVE MATERIALS**"

- A properly completed *Radioactive Waste Disposal Form* (yellow waste card) located near (not attached to) the waste containers so that it is apparent which container they are associated with. (See *Section 9.1* of this guide for instructions on documenting waste on the disposal form.)

WASTE ACCEPTANCE CONDITIONS

Solid RAM waste containers shall **not** contain the following:

- Free−standing liquids
- Lead
- Metals
- Biohazard material (biosafety level 1 [BSL−1] or greater, see *Section 9.7, Mixed Radioactive and Biological Waste*)
- Biohazard bags
- Sharps and puncture hazards (see *Section 9.9, Sharps with Radioactive Contamination*)

- > 5% polyvinyl chloride (PVC) (weight or volume)
- Sealed radioactive sources
- Resource Conservation and Recovery Act (RCRA) hazardous wastes
- Explosives
- Pyrophoric materials

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

SEGREGATION SCHEME: SOLID RAM WASTE

Solid RAM waste must be segregated based on the half−life of the radioisotope 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…for ONLY H−3 and C−14**
- Waste with half−life **> 120 days…for RAM other than H−3 and C−14** (e.g., Ca−45, Cl−36)

9.3 LIQUID RAM WASTE

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

Drain disposal of radioactive liquid waste is *strictly prohibited* in the lab.
All liquid waste must be offered to REHS for disposal.

CONTAINER TYPES

Liquid RAM waste should be collected in any of the following:

- 1− or 2.5−gallon (equivalent to about 4 or 10 liters, respectively) polyethylene carboys and stored in a secondary container (all provided by REHS)
- Waste containers can also be purchased by the lab, provided ALL of the following criteria are met:
    - Must be rigid plastic (not glass)
    - Must have properly fitted, screw top lids
    - Must be stored in secondary containment
    - Must be used with the understanding that they will not be returned for reuse

CONTAINER LABELING

Liquid RAM waste containers shall be appropriately labeled with ALL of the following:

- Radiation warning "trefoil" symbol

- The words "**CAUTION RADIOACTIVE MATERIALS**"
- A properly completed *Radioactive Waste Disposal Form* (yellow waste card) located near (not attached to) the waste containers so that it is apparent which container they are associated with. (See *Section 9.1* of this guide for instructions on documenting waste on the disposal form.)

WASTE ACCEPTANCE CONDITIONS

- Liquid RAM waste containers must not be overfilled (load to fill line on REHS−supplied containers).
- Do not commingle liquid RAM waste with other waste streams (e.g., solid, liquid scintillation vials, animal carcasses/tissues).
- Liquid RAM waste containers shall be stored in secondary containment.
- Do not leave funnels in RAM waste containers (re−cap container when not pouring waste).
- Liquid RAM waste should have a pH between 6 and 9.
    - Neutralization is performed as a final step in experimental procedures prior to disposal.
    - If waste has been added to the container and has a pH range ≤ 2 or ≥ 12.5, follow *mixed waste* procedures in *Section 9.4 and/or 9.7*.
- Disinfect biohazard material (for BSL−1 or greater, see *Section 9.7, Mixed Radioactive and Biological Waste*).

SEGREGATION SCHEME: LIQUID RAM WASTE

Liquid RAM waste must be segregated based on the half−life of the radioisotope 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…for ONLY H−3 and C−14**
- Waste with half−life **> 120 days…for RAM other than H−3 and C−14** (e.g., Ca−45, Cl−36)

9.4 MIXED RADIOACTIVE AND HAZARDOUS CHEMICAL WASTE

Mixed waste consists of radioactive waste with additional hazardous component(s), e.g., flammable, corrosive, reactive, or poisonous. Some common procedures performed in the laboratory that may generate mixed waste are high−performance liquid chromatography analysis, phenol/chloroform extractions, precipitation reactions utilizing trichloroacetic acid, and the use of certain hazardous liquid scintillation cocktails. A list of non−hazardous scintillation cocktails is available on the REHS radiation safety website and in the *Appendices* of this guide.

If mixed waste is currently generated in the lab and you have not previously notified REHS, contact REHS immediately. If your lab anticipates generating mixed wastes:

- Contact REHS prior to the generation of mixed waste to help establish disposal procedures and waste minimization plans. Disposing of mixed waste may be extremely costly; therefore, waste minimization should be a critical component of your experimental protocols.
- Mixed waste containers shall be appropriately labeled with ALL of the following:
  - The radiation trefoil symbol
  - The words "**CAUTION RADIOACTIVE MATERIALS**"

  - A properly completed *Radioactive Waste Disposal Form* (yellow waste card) located near (not attached to) the waste containers so that it is apparent which container they are associated with. Document all hazardous and non−hazardous constituents in Section III of the disposal form (e.g., water 80%, ethanol 10%, acetic acid 10%). (See *Section 9.1* of this guide for instructions on documenting waste on the disposal form.)
  - A properly filled out black and white "Hazardous Waste" label

9.5 LIQUID SCINTILLATION VIALS

CONTAINER TYPES

Liquid scintillation vial (LSV) waste can be collected in any of the following:

- 30− or 55−gallon drums that have two (2) liners (provided by REHS)
- Waste containers can also be purchased by the lab, provided ALL of the following criteria are met:
  - Must be a rigid material (capable of containing liquid)
  - Must have a capacity of 10 gallons or less
  - Must have two (2) liners (REHS can provide plastic liners)
  - 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 marking and labeling requirements of a radioactive waste container.

CONTAINER LABELING

The LSV waste containers shall be appropriately labeled with ALL of the following:

- Radiation warning "trefoil" symbol
- The words "**CAUTION RADIOACTIVE MATERIALS**"

- A properly completed *Radioactive Waste Disposal Form* (yellow waste card) located near (not attached to) the waste containers so that it is apparent which container they are associated with. Document the full name of the scintillation fluid in Section III of the disposal form.
  (See *Section 9.1* of this guide for instructions on documenting waste on the disposal form.)

- A properly filled out black and white "Hazardous Waste" label if the cocktail used is not on the "safe" scintillation cocktail list available on the REHS radiation safety website and in the *Appendices* of this guide.

LSV WASTE THAT IS CONSISTENT WITH BACKGROUND

For LSV waste that is **determined to be consistent with background** (which can include LSVs used for wipe tests, self−normalization and calibration [SNC] verification, etc.):

- Use a waste container dedicated to LSVs that are consistent with background; store them in the RAM waste storage area.
- Follow all labeling and disposal form instructions as stated immediately above in the ***Container Labeling*** section, as waste containers still need to be managed and labeled as RAM waste.
- On the *Radioactive Waste Disposal Form* (yellow waste card), fill it out as usual (include isotopes and LSC cocktail info), but write "***trace (wipe tests and SNC verification only)***" in any fields used to document activity.

WASTE ACCEPTANCE CONDITIONS

- Do not commingle LSV waste with other waste streams (e.g., solids, liquids, animal/biological).
- Do not place small vials of stock solutions in liquid scintillation vial waste.
- Liquid scintillation vials must be capped. If the liquid leaks, it might degrade the plastic liner.
- Waste containers must not be overfilled, and the container's lid must fit properly.
- Use approved non−hazardous scintillation fluid unless otherwise authorized. A list of approved, "safe" scintillation cocktails is available on the REHS radiation safety website and in the *Appendices* of this guide.
- The full name of the liquid scintillation cocktail should be documented in Section III of the yellow *Radioactive Waste Disposal Form*.
- LSV waste containing H−3 and C−14 in concentrations that are greater than 0.05 microcuries per gram (µCi/g) may require special consideration (0.95 mCi/30−gallon drum and 1.75 mCi/55−gallon drum). Contact REHS if your lab plans to generate LSVs that exceed these activities.
- If one LSV has significantly more activity (approximately 0.5 mCi or greater) than the rest of the LSV waste, place it in a separate waste container for pick−up.

SEGREGATION SCHEME: LIQUID SCINTILLATION VIALS

Liquid scintillation vial waste must be segregated by radionuclide 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…for ONLY H−3 and C−14**
- Waste with half−life **> 120 days…for RAM other than H−3 and C−14** (e.g., Ca−45, Cl−36)

9.6 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 and storage equipment to accommodate the full volume of their anticipated waste for at least three (3) months.

CONTAINER TYPES

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

CONTAINER LABELING

Animal carcass/tissue waste containers shall be appropriately labeled with ALL of the following:

- Radiation warning "trefoil" symbol
- The words "**CAUTION RADIOACTIVE MATERIALS**"

- A properly completed *Radioactive Waste Disposal Form* (yellow waste card) located near (not attached to) the waste containers so that it is apparent which container they are associated with. (See *Section 9.1* of this guide for instructions on documenting waste on the disposal form.)

WASTE ACCEPTANCE CONDITIONS

- Do not commingle animal carcass/tissue waste with other waste streams (e.g., solids, liquids, LSV).
- Keep animal carcasses and tissues frozen until removal by REHS personnel.
- Prevent sharp edges from puncturing the sealed double bags.
- Deceased animals contaminated with H−3 and C−14 at a concentration less than 0.05 µCi/g can be disposed of as non−radioactive waste by REHS. When radioactivity is concentrated in specific organs, these parts may be removed for radioactive waste disposal as tissues. 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/g.
- Deceased animals containing radionuclides with a half−life of less than 120 days will be held for decay to background.
- Deceased animals known to contain active pathogens and radioactive materials must receive special attention; REHS must be notified prior to disposal.

SEGREGATION SCHEME: ANIMAL CARCASS/TISSUE

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

- Waste with half−life **< 120 days** (e.g., I−125, S−35, P−32, P−33, Cr−51)
- Waste **containing only H−3 and/or C−14**
- Waste with half−life **> 120 days…for RAM other than H−3 and C−14**

9.7 MIXED RADIOACTIVE AND BIOLOGICAL WASTE

Radioactive waste that contains biohazardous agents (i.e., BSL−1 or greater) must be biologically decontaminated prior to REHS pick−up. Some general guidelines are provided below, but many laboratories have unique protocols; therefore, these recommendations will not fit every situation. Contact the RSO and/or the REHS Biosafety group (email: biosafety@rutgers.edu) to discuss specific mixed biological/radioactive waste situations and 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 REHS Biosafety Group to discuss the situation 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.
- For disinfectant options, consult the Rutgers University Biological Safety Guide to choose a disinfectant that is chemically compatible with the waste materials being treated. Chemical compatibility charts can be found on the REHS website here:

  https://ipo.rutgers.edu/rehs/safety/lab/chemical-compatibility

  **** WARNING ****
  Toxic gases can be released by mixing incompatible chemicals, e.g., bleach & ammonia, bleach & iodine.

- Solid items that are 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 disinfectant chemical(s) used on the *Radioactive Waste Disposal Form*.
- Do not attempt to decontaminate sharps that contain both biohazards and radioactive materials *(see Section 9.9, Sharps with Radioactive Contamination)*.

9.8 GENERALLY LICENSED SOURCE MATERIAL WASTE

While naturally radioactive, generally licensed source material must be disposed of as hazardous waste. Submit a hazardous waste disposal request to REHS via the following website link:

https://halflife.rutgers.edu/forms/hazwaste.php

(In the "Other Information" field, enter a statement that the waste contains uranium or thorium, and include the compound name, e.g., uranyl acetate, uranyl nitrate, thorium oxide, etc.)

For more information, see *Section 11, Generally Licensed Source Material*.

9.9 SHARPS WITH RADIOACTIVE CONTAMINATION

Sharps are generally considered as items with sharp points or cutting edges that are capable of causing injury to a worker handling the item. Sharps that were used in (1) animal or human patient care or treatment, (2) medical research, or (3) industrial laboratories can be contaminated with a hazard (chemical, biological, RAM, etc.); therefore, careful handling of contaminated sharps and use of PPE can prevent injury and reduce the risk of infection.

Examples of sharps include but are not limited to:

- Needles – e.g., biopsy needles, hypodermic needles, needles with attached tubing or filters, etc.
- Syringes – with or without needle (don't remove, bend, or recap the needles!)
- Pasteur pipettes
- Scalpel/razor blades
- Blood vials and capillary tubes (animal or human)
- Specific glass culture dishes
- Glass slides and cover slips
- Broken glass
- Scissors/tweezers (metal)

CONTAINER TYPES

Radioactive sharps waste must only be collected in approved sharps containers. The waste generator is responsible for purchasing sharps disposal containers.

CONTAINER LABELING

Radioactive sharps waste containers shall be appropriately labeled with ALL of the following:

- Radiation warning "trefoil" symbol
- The words "**CAUTION RADIOACTIVE MATERIALS**"

- A properly completed *Radioactive Waste Disposal Form* (yellow waste card) located near (not attached to) the waste containers so that it is apparent which container they are associated with. (See *Section 9.1* of this guide for instructions on documenting waste on the disposal form.)

WASTE ACCEPTANCE CONDITIONS

- Containers holding radioactive sharps must be sealed, properly labeled, and presented for disposal as radioactive waste.
- Do not place sharps containers into solid RAM waste containers.
- Ensure all biohazard symbols and words are crossed out if no such hazard is present.

SEGREGATION SCHEME: RAM SHARPS

RAM sharps waste must be segregated based on the half−life of the radioisotope 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…for ONLY H−3 and C−14**
- Waste with half−life **> 120 days…for RAM other than H−3 and C−14** (e.g., Ca−45, Cl−36)

SHARPS HANDLING AND DISPOSAL

- Contaminated sharps must never be sheared or broken.
- Do not cap syringe needles before placing them in the sharps containers. However, if recapping is necessary, workers must use either a mechanical device or a one−handed technique. The cap must not be held in one hand while guiding the needle into it or placing it over the needle.

  A one−handed "scoop" technique involves the worker holding the body of the syringe and using the needle itself to pick up the cap. Then, the cap is pushed against a hard surface to ensure a tight fit onto the needle. The cap may be held with tongs or forceps during placement over needle.
- Contaminated broken glass must not be picked up by hand but must be cleaned up using mechanical means, such as a brush/dustpan, tongs, or forceps.

The presence of loose sharps intermixed with solid waste represents a significant hazard to lab and REHS personnel. It constitutes a serious violation that could result in revocation of the Authoree's permit.

9.10 REQUEST FOR RADIOACTIVE WASTE REMOVAL

To request a radioactive waste pick−up, submit the *Request for Radioactive Waste Disposal* form via the REHS website (https://halflife.rutgers.edu/forms/radwaste.php) or call REHS at 848−445−2550.

REHS will remove the radioactive waste from the lab up to 5 or 10 working days from the date of the waste removal request (depending on the campus location of the lab); therefore, please plan accordingly.

When you contact REHS, have the following information ready.

- Authoree/PI name and PI number (4−digit permit number)
- Building and lab/room where radioactive waste is stored
- Type of waste (solid, liquid, LSVs, animal)
- Radionuclides present in waste
- Yellow waste card ticket number(s) (located on the bottom right side of the card)
- Quantity and size of waste containers

10. SEALED SOURCES (INCLUDING GLDs)

10.1 DESCRIPTION OF SEALED SOURCES

A sealed radioactive source ("sealed source;" SS) is a radioactive material that is encased in a capsule designed to prevent the source from escaping or being released under normal conditions. For this reason, many of the policies and procedures regarding contamination control are not required for sealed sources. Some sealed sources have very low activity and do not present a significant hazard from the dose rates emitted. However, some sealed sources have relatively large activities that may present a significant source of external radiation exposure; therefore, they must be handled carefully. Any sealed source that could present a moderate or significant external radiation hazard will be *specifically licensed* and will require RSO/RSC approval for use.

Examples of sealed sources used at the University include but are not limited to:

- Check sources (loose or mounted to the side of G-M survey meter)
- Static eliminators (used when working with fine powders)
- Electron capture devices (specific detectors mounted in some gas chromatographs)
- Isotopic-based X−ray fluorescence units (commonly used to identify metals in soil and paint)
- Soil moisture/density gauges
- Irradiators (ablate rodent immune systems/treat feeder cells)

EXPOSURE AND CONTAMINATION POTENTIAL

Contamination Potential: Low, as sealed sources are designed to prevent dispersal.

Low Exposure Potential Sources: The majority of sealed sources at the University have very low activity or utilize isotopes that are not energetic enough to be a source of external exposure. Examples include but are not limited to check sources, static eliminators, and electron capture devices.

High Exposure Potential Sources: Some sealed sources have relatively large activities that may present a significant source of external radiation exposure; therefore, they must be handled carefully. Examples include but are not limited to isotopic−based X−ray fluorescence units, soil moisture/density gauges, and any source used to irradiate samples or cells in the laboratory environment. Only trained laboratory workers may work with high exposure potential sealed sources.

10.2 AUTHORIZATION TO USE SEALED SOURCES

LICENSING AND AUTHORIZATION TO USE SEALED SOURCES

Possession of any sealed source at the University requires the PI to submit a permit application to REHS. See *Section 4.1, Authorization To Use Radioactive Materials*, for more information and the link to the application. For additional permit information, management, and changes, refer to *Section 4.4, Permit Renewal and Amendments*, and *Section 4.5, Permit Inactivation, Termination, & Reactivation*.

IMPORTANT: REHS must be notified whenever a sealed source will be purchased, transferred, relocated, or to request disposal of a source. REHS conducts inventory verification every 6 months to maintain an inventory of all sealed sources possessed at the University per NJDEP regulations.

NOTE: With few exceptions, sealed sources are regulated as licensed material under the University's *specific license* issued by the NJDEP. All other sealed sources not licensed under a *specific license* are considered *generally licensed devices (GLD)* or are exempt from regulatory control. Upon receipt of your permit application for using sealed sources, the RSO will determine if your sources are specifically licensed, generally licensed, or exempt. For more information on generally licensed devices, see *Section 10.4, Generally Licensed Devices*.

AUTHOREE RESPONSIBILITIES FOR SEALED SOURCES

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

1. Attend radiation safety training at the required frequency.
2. Ensure that all radiation workers attend radiation safety training at the required frequency.
3. Ensure that all radiation workers receive in−lab training specific to the procedures and experiments authorized in the permit.
4. Ensure that sealed sources are used only in approved locations listed on the permit.
5. Inform all non−radiation workers of the potential health hazards of radiation and the established safeguards to ensure a safe workplace.
6. Administer and enforce the radiation safety rules and regulations outlined in this guide and other University policies.
7. Notify the RSO of any prolonged absences or sabbaticals in excess of four (4) consecutive weeks. The RSO and Authoree will jointly determine if the Authoree can maintain oversight of RAM or if a temporary/alternate supervisor is warranted.
8. Ensure security of sealed sources, both when in use and in storage. Examples include the use of lock boxes or locked cabinets when sources are not in use, as well as line of sight observation or locked labs when sources are in use.
9. Maintain current inventory of all sealed sources possessed.
10. Notify the RSO **before** acquiring individual sealed sources or equipment that may contain a sealed source(s). Examples of equipment that may contain sealed sources include but are not limited to:
    - Isotopic−based x−ray fluorescence unit
    - Moisture and/or density gauges
    - Fill−level gauges
    - Isotopic−based particle counters/sizers
    - Self−shielded irradiators

11. **Loss or improper disposal of sealed sources must be reported immediately to REHS**.
12. The majority of Authorees and/or lab workers handling sealed sources will be enrolled in REHS' dosimetry program. It is the Authoree's responsibility to ensure dosimetry is worn properly.

WASTE DISPOSAL REQUIREMENTS

Sealed sources must be disposed of as solid radioactive waste. Refer to *Section 9.2, Solid (Dry) RAM Waste*, and *Section 9.1, Radioactive Waste Disposal Forms*, for instructions on disposing of sealed sources at the University. Removal of GLDs and/or the radioactive source from GLDs **MUST** be performed by REHS radiation safety staff. For assistance, please contact REHS at radgroup@ipo.rutgers.edu or 848-445-2550.

10.3 SEMI-ANNUAL INVENTORY AND LEAK TESTS

SEMI-ANNUAL INVENTORY

All sealed sources must be accounted for on at least a semi-annual (every 6 months) basis. Inventory verification will take the form of Inventory Verification Reports (IVRs) sent to the Authoree and/or visual confirmation by REHS personnel.

SEMI-ANNUAL LEAK TESTS

A subset of sealed sources must be inspected and tested for leakage every 6 months. The wipe tests are performed by REHS personnel.

10.4 GENERALLY LICENSED DEVICES

This section describes and provides examples of generally licensed devices (GLDs). All GLDs contain sealed sources, but not all sealed sources are GLDs. While there are subtle differences in how REHS manages regulatory compliance between sealed sources that are or are not contained within GLDs, these differences are not discernable to Rutgers' research community. Therefore, if you anticipate possessing any GLD, REHS requests that you follow the guidance regarding authorization, inventory, wipe tests, security, transfers, and disposal of sealed sources found in *Sections 10.1-10.4*.

A generally licensed device usually consists of radioactive material contained as a sealed source within a shielded device. GLDs have safety features engineered into the design, and direct handling of the radiation source is very difficult under normal operating conditions.

Examples include but are not limited to the following:

- Gas chromatographs with electron capture detectors (Ni−63)
- Liquid scintillation counters* (Cs−137 or Ba−133)
- Particle counters (Kr-85)
- Static elimination devices (Po−210)
- Some check sources (various isotopes)
- Self−luminous exit signs (H−3)

10.5 IRRADIATORS

The University has a number of low−dose irradiators on campus typically used to deliver relatively high radiation doses to cells and/or research animals. While inherently safe due to their design and appropriate shielding, they do contain high−activity sources. For this reason, the federal government has developed robust security regulations (10 CFR Part 37) surrounding these irradiators. As such, the use of self−shielded irradiators requires pre−approval by REHS, fingerprinting, FBI criminal history check, and special training. If you require the use of a self−shielded irradiator, contact REHS several months in advance to start the security screening process. For any questions regarding irradiators, contact REHS.

10.6 TRAINING & DOSIMETRY: SEALED SOURCES & GLDs

For detailed information on training, see *Section 13, Radiation Safety Trainings*.
For detailed information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

10.7 LAB POSTING & SIGNAGE REQUIREMENTS: SEALED SOURCES & GLDs

SEALED SOURCE AND GLD REQUIREMENTS

The required signage for a lab that contains sealed sources and/or GLDs includes all of the following, which will be discussed in this section:

- Caution sign
- Caution labels
- REHS' ***Radioactive Materials Laboratory Safety Rules*** poster
- NJDEP's ***Notice to Employees***

Please notify REHS if the lab has sealed sources and/or GLDs that are not properly labeled or if the existing signs/labels have been compromised.

NOTE: *Lab Posting & Signage Requirements* for other radiation sources: (1) for licensed RAM (open source), refer to *Section 4.1, Authorization to Use Radioactive Materials*; (2) for radiation−producing machines, refer to *Section 12, Radiation−Producing Machines*.

CAUTION SIGN

For any lab that contains hazardous materials, a sign with caution/warning alerts ("caution sign") must be posted at every entrance to the lab (on the door or immediately adjacent wall). The Authoree/PI is responsible for ensuring a caution sign is present at all entrances to their lab(s) and requesting a new or replacement sign if it is absent/compromised or when labels are incorrect or missing. To submit a caution sign request to REHS, the Authoree/PI/lab manager can complete and submit the form at this website:
http://halflife.rutgers.edu/forms/cautionsign.php

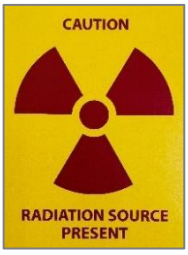
When REHS receives the request, they will create a caution sign with all applicable caution labels affixed. REHS is responsible for posting the proper caution sign at entrances to laboratories, equipment rooms, and other work areas where hazardous materials, including sealed sources/GLDs, may be used or stored.

The following information should be listed on the caution sign at each active sealed source and/or GLD lab entrance:

- Caution labels for all hazards, including a radiation hazard label containing the following:
  - Radiation warning "trefoil" symbol 
  - The words "**CAUTION RADIATION/RADIOACTIVE SOURCE PRESENT**" or "**CAUTION RADIOACTIVE MATERIALS**"
- The primary person to contact in the event of an emergency. Acceptable primary contacts include the Authoree/PI, lab manager, room supervisor, or lab technician.
- A secondary contact person if the primary contact is not available in the event of an emergency.
- The contact's name, campus address (building and room number), and campus phone number should be listed and updated to maintain current information.

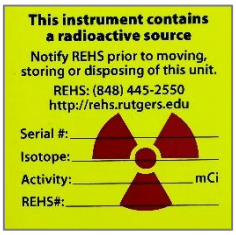
CAUTION LABELS

Caution labels provide warnings and information about hazards, such as RAM, sealed radioactive sources, and GLDs, and can be in the form of stickers or tape (both are available in various sizes) that can be affixed to various places. Any equipment or storage container that contains a sealed source and/or GLD must be labeled with a visible caution label that contains and states both of the following:



- Radiation warning "trefoil" symbol
- The words "**CAUTION RADIATION/RADIOACTIVE SOURCE PRESENT**" or "**CAUTION RADIOACTIVE MATERIALS**"

An informational label is also required on all equipment with radioactive sources, including GLDs:



- A label containing the words "**This instrument contains a radioactive source**" and information, such as the serial #, isotope, activity, & REHS identification #.

(See the *Appendices* of this guide for a listing of radiation caution signs/labels.)

OTHER REQUIRED POSTINGS

REHS is responsible for posting the following in every lab where sealed sources and/or GLDs are stored or handled:

- REHS' ***Radioactive Materials Laboratory Safety Rules*** poster
- NJDEP's ***Notice to Employees*** (describing standards for protection against radiation)

The Authoree/PI is responsible for ensuring these postings are present in their lab(s) and requesting a new or replacement posting if any are absent or compromised.

11. GENERALLY LICENSED SOURCE MATERIAL

NOTE: Generally licensed source material does not include generally licensed devices. Generally licensed devices are discussed in Section 10, Sealed Sources (Including GLDs).

11.1 DESCRIPTION OF GENERALLY LICENSED SOURCE MATERIALS

In this guide, the default regulatory descriptor of RAM has been "licensed" material. These materials may be *specifically* or *generally* licensed (see *Section 4, Radioactive Materials – Regulatory Authority*).

"Licensed" materials (whether *specifically* or *generally* licensed) are divided into three (3) main categories:

1. **Byproduct material**: approximately 99% of RAM used at the University.
2. **Source material**: uranium and thorium compounds that are relevant to this section of the guide
3. **Special nuclear material**: a special category - materials that are enriched in the isotope U–235, or materials containing plutonium

This section is specific to **source material**. The categories of licensed material mentioned above illustrate the distinction between source material and the other 2 categories.

Generally licensed source material (GLSM) consists of compounds or chemicals that contain uranium (U) or thorium (Th) used in small quantities. In essence, if you use sub-kilogram quantities of any compound(s) containing uranium or thorium, you possess GLSM. (Typical inventories found in the laboratory environment consist of 10– to 200–gram containers of uranium or thorium and/or their compounds.)

Examples include but are not limited to:

- U-238 powders or filings
- Uranyl acetate (electron microscopy)
- Uranyl formate
- Uranyl nitrate
- Uranyl oxide
- Sodium uranate
- Th-232 powders or filings
- Thorium nitrate
- Thorium oxide

11.2 AUTHORIZATION TO USE GLSM

LICENSING AND AUTHORIZATION TO USE SEALED SOURCES

In New Jersey, the NJDEP, pursuant to N.J.A.C. 7:28-58.1 (10 CFR Part 40 incorporated by reference), is responsible for licensing and regulating the ownership, receipt, acquisition, possession, use, and transfer of radioactive "source material" by issuing a *general license* to a purchaser.

Essentially, a general license means anyone may purchase or use these materials. That said, there are still some regulatory requirements surrounding the use of these materials, which include the following:

- Maintaining a proper inventory of GLSM
- Proper disposal of GLSM (see below)
- Maintaining security

- Conform with DOT requirements when transferring materials
- Do not exceed annual limits on quantities transferred

Many who take advantage of this general license to purchase and use uranium and thorium compounds may not be aware of the above regulatory requirements. While the use of GLSM does not fall under Rutgers' RAM license, REHS has the infrastructure that supports the RAM license and the technical understanding to assist Rutgers' researchers who use GLSM to comply with the regulatory requirements. To this end, REHS asks you to:

- Notify REHS when you intend to purchase GLSM
- Notify REHS if you currently possess GLSM and did not notify REHS upon purchase
- Notify REHS if transferring GLSM to another lab (within or outside of the University)
- Maintain an accurate inventory (in grams) of GLSM on hand
- Dispose of GLSM ONLY via REHS as hazardous waste

WASTE DISPOSAL REQUIREMENTS

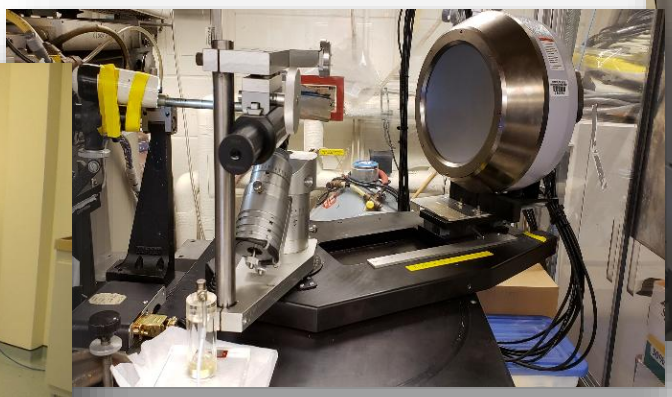
While naturally radioactive, GLSM must be disposed of as hazardous waste. Submit a hazardous waste disposal request to REHS via the following website link:

https://halflife.rutgers.edu/forms/hazwaste.php

(In the "*Other Information"* field, enter a statement that the waste contains uranium or thorium, and include the compound name, e.g., uranyl acetate, uranyl nitrate, thorium oxide, etc.)

END OF THE RADIOACTIVE MATERIALS SECTION.

RADIATION PRODUCING MACHINES SECTION



12. RADIATION–PRODUCING MACHINES

For the purposes of this guide, the terms "Authoree" and "Principal Investigator (PI)" are used interchangeably to describe a PI who is authorized for RAM or RPM use.

A radiation–producing machine (RPM) is a device that produces and emits X–ray or gamma radiation. Generally, RPMs can be categorized as analytic, diagnostic, or therapeutic. Examples of RPMs include X–ray machines of the standard diagnostic and therapeutic types, X–ray diffraction units, X–ray crystallography units, electron microscopes, particle accelerators, etc. The NJDEP regulates and registers the use of RPMs.

12.1 AUTHORIZATION TO USE RPMs

Any person wishing to be an Authoree with administrative control of and responsibility for an RPM must meet the minimum criteria outlined below and apply for authorization to use an RPM. The application form is available on the REHS radiation safety website in the section titled *Applications for Radioactive Material and Radiation–Producing Machine Use* (include attachments, if necessary). After REHS receives the application, radiation safety staff will contact the applicant to schedule an appointment to discuss the rules and regulations for RPMs. Typical uses for RPMs at the University include X–ray diffraction, X–ray fluorescence, electron microscopy, ion–milling, animal imaging, and clinical uses in the practice of medicine.

A. MINIMUM REQUIREMENTS

The minimum criteria are as follows:

- Hold a faculty or staff position of Instructor, Research Associate, or equivalent/higher rank.
    - Authoree candidates who do not meet the positional requirements above will be considered at the request of the department chair.
- Have at least six (6) months of experience working with RPMs.
- Complete X–ray safety training.

B. APPLICATION AND APPROVAL

The permit application for RPM use can be found in the "*Applications for Radioactive Material and Radiation–Producing Machine Use*" section on the REHS radiation safety website.

The RSO or their designee will review the application, conduct an interview (if necessary), and the RSO will approve or deny the application.

C. POLICY ON RPM USE ON HUMANS

Use of ionizing radiation from a machine source, e.g., computed tomography (CT), X–ray, DEXA scan, etc., must be approved by the Institutional Review Board (link to website).

D. ANIMAL/IN−VIVO WORK

The University's Institutional Animal Care & Use Committee (IACUC) reviews and approves all protocols involving animals. Animal protocols involving X−ray machines, RAM, and/or irradiators are forwarded to REHS for review. REHS will review each protocol on an individual basis, then 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 animal cages and rooms
- Disposal of deceased 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 RAM permit application*
- The radionuclide and/or activity are not currently authorized*
- The protocol presents a significant variation on currently accepted research practices

*Applicable only when radioactive materials are used in conjunction with RPMs. An example would be the use of F−18 in PET/CT protocols.

12.2 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 the RPM 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 RPM(s) under the Authoree's authorization.
- Correction of any non−compliance issues noted during inspection.
- Ensure proper use and exchange of dosimeters (e.g., whole body badges, extremity badges) for workers assigned to their authorization. **NOTE**: if dosimeters are not exchanged for two (2) cycles for any worker, the Authoree may be required to pay for the non−returned/lost dosimetry fees.
- Ensure all users of radiation−producing machines comply 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; ensure the SOP is available to all users. Verify that all users are properly trained to use that specific machine.
- Provide and maintain a written, detailed SOP for alignment procedures (if applicable). REHS must approve all users who perform alignment.

The Authoree should notify REHS immediately in the following circumstances:

- If an overexposure to radiation is indicated or suspected.
- Upon failure of an interlock or fail−safe device.
- Before any machine is moved, transferred, or disposed of.
- When changes in experimental design could result in significant radiation exposure or hazard.

12.3 PERMIT AMENDMENTS & TERMINATION

Radiation−producing machine permits are maintained without an expiration date. The following permit amendments are handled between the Authoree and RSO:

- Acquisition of new RPMs
- Removal of current RPMs
    - Disposal of unit, e.g., junk, donate, or sell
    - Storage of unit not currently in use (allows Rutgers to keep unit without paying annual NJDEP fees)
    - Transfer of unit to another Authoree within Rutgers
- Relocation of RPMs, including relocation within the same room
- When a new worker in the lab wishes to perform alignment and/or a new alignment procedure
- Termination of the permit/registration

Authorees desiring to amend or terminate their permit shall submit a written request to the RSO.

12.4 RPM ACQUISITION, REGISTRATION, AND INITIAL INSPECTION

REHS must be notified prior to the acquisition of any RPM to ensure adequate and safely constructed facilities and trained personnel are available. After receipt of an RPM 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 or confirming the unit's interlock systems and warning lights for fail−safe characteristics
- Issuance of dosimetry badges for new users
- Assess training compliance of all users
- Evaluate the operating manual and/or standard operating procedures (SOP)
- Creation of logbook
- Assess alignment SOP and approval of qualified individuals (if applicable)
- Security of unit and interlock checks
- Posting of appropriate signs and labels

REHS will interpret the NJDEP regulations and provide assistance regarding NJDEP compliance to the Authoree. Upon completion of training and a satisfactory inspection, REHS is responsible for registering the RPM with the NJDEP, granting authorization to the applicant, and maintaining the NJDEP registration thereafter (including disposition or transfer of the unit, requiring termination of the registration).

The authorization permits the use of only the specific radiation−producing machine(s) identified in the application. If any RPM is moved (including being relocated within the same lab), the Authoree shall notify REHS. If the Authoree wishes to obtain additional RPM units, they will need prior approval from REHS. Any new units added to the Authoree's permit will require an initial inspection and survey of the unit as well as registration with the NJDEP, as outlined above.

12.5 RPM TRAINING & DOSIMETRY

For detailed information on training, see *Section 13, Radiation Safety Trainings*.
For detailed information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

12.6 LAB POSTING & SIGNAGE REQUIREMENTS: RPM

The required signage for an RPM lab includes all of the following, which will be discussed in this section:

- Caution sign
- Caution labels
- REHS' ***Laboratory Safety Rules*** poster specific to the type of RPM (e.g., X−ray, Electron Microscope, Analytical X−ray Device)
- NJDEP's ***Notice to Employees***
- NJDEP's Registration form for each RPM

Please notify REHS if the lab has RPMs that are not appropriately labeled or if the existing signs/labels have been compromised.

NOTE: *Lab Posting & Signage Requirements* for other radiation sources: (1) for sealed radioactive sources and generally licensed materials/devices, refer to *Section 10, Sealed Sources (Including GLDs)*; (2) for licensed RAM (open source), refer to *Section 4.1, Authorization to Use Radioactive Materials*.

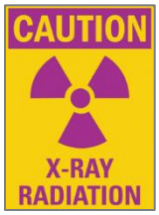
CAUTION SIGN

For any lab that contains hazardous materials, a sign with caution/warning alerts ("caution sign") must be posted at every entrance to the lab (on the door or immediately adjacent wall). The Authoree/PI is responsible for ensuring a caution sign is present at all entrances to their lab(s) and requesting a new or replacement sign if it is absent/compromised or when labels are incorrect or missing. To submit a caution sign request to REHS, the Authoree/PI/lab manager can complete and submit the form at this website:

http://halflife.rutgers.edu/forms/cautionsign.php

When REHS receives the request, they will create a caution sign with all applicable caution labels affixed. REHS is responsible for posting the proper caution sign at entrances to laboratories, equipment rooms, and other work areas where hazardous materials, including RPMs, may be used or stored.

The following information should be listed on the caution sign at each active X−ray lab entrance:



- Caution labels for all hazards, including a radiation hazard label containing the following:
    - Radiation warning "trefoil" symbol
    - The words "**CAUTION X−RAYS**" or "**CAUTION X−RAY RADIATION**"
- The primary person to contact in the event of an emergency. Acceptable primary contacts include the Authoree/PI, lab manager, room supervisor, or lab technician.
- A secondary contact person if the primary contact is not available in the event of an emergency.
- The contact's name, campus address (building and room number), and campus phone number should be listed and updated to maintain current information.

CAUTION LABELS

Caution labels provide warnings and information about hazards, such as RPMs, and can be in the form of stickers or tape (both are available in various sizes) that can be affixed to various places.

Caution labels, informational tags, and warning lights may be required if applicable per the type of RPM:

- "**CAUTION: THIS EQUIPMENT PRODUCES X−RAYS**" label to be located near the switch that energizes the X−ray tube

- "**CAUTION: HIGH INTENSITY X−RAY BEAM**" label to be located near the X−ray tube housing

- RPM unit information tag to be located on the RPM (info contained on tag/label includes NJDEP registration #, Authoree, RPM manufacturer, unit model #, unit serial #, and REHS inventory #)

- For nearly all of the analytical X−ray units at the University, a clearly visible warning light with fail−safe characteristics labeled with the words "**X−RAY ON**" that is illuminated only when the X−ray tube is energized. This hazard communication is built into most units; however, some units need a label stating "**X−RAY ON**" manually affixed next to the warning light.

(See the *Appendices* of this guide for a listing of radiation caution signs/labels.)

OTHER REQUIRED POSTINGS

REHS is responsible for posting the following in every X−ray lab:

- REHS' ***X−ray Laboratory Safety Rules*** poster
- NJDEP's ***Notice to Employees*** (describing standards for protection against radiation)
- NJDEP's Registration form for each RPM

The Authoree/PI is responsible for ensuring these postings are present in their lab(s) and requesting a new or replacement posting if any are absent or compromised.

12.7 RELOCATION, REPAIRS, TRANSFERS, & DISPOSAL OF RPMs

RELOCATION AND REPAIRS/MODIFICATIONS

The relocation, repair, or modification of an RPM can alter the functionality and radiation output of the machine. For any RPM that is moved to a different location, the NJDEP requires notification and a re−survey of the unit. To meet this NJDEP requirement, the Authoree must notify REHS:

- Before or immediately after relocating an RPM to another lab or within the same lab
- Immediately after an RPM has been repaired or modified

It is the responsibility of REHS to complete the following (when applicable):

- Survey the RPM and lab
- Amend the unit's registration with the NJDEP

TRANSFERS OR DISPOSALS

Prior to the transfer or disposal of any RPM, the Authoree must contact REHS for the appropriate instructions and steps.

For RPM disposal, the Authoree must follow proper disposal methods through an approved vendor, and REHS must submit a disposition form to the NJDEP to terminate the unit's registration and associated fees.

12.8 INSPECTIONS AND ENFORCEMENT

Upon completion of bi−annual (or annual in the case of electron microscopes) inspections, REHS will send each Authoree a copy of the inspection report. Any issues of non−compliance will be noted on these reports, and the Authoree is expected to correct any issues in a timely manner. If the inspector notes any major noncompliance issues and/or repeated minor noncompliance issues, an NOV may be issued to the Authoree. A written response outlining the corrective measures taken by the Authoree is required within two (2) weeks. If two (2) NOVs are issued within three (3) inspection cycles, a management meeting may be required at the discretion of the RSC, including attendance by the Authoree, RSO, and at least one member of the RSC. If the unit is deemed to pose an immediate safety hazard at any time, REHS will prohibit the use of the unit until corrective actions have been taken.

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

Examples of **MINOR** non−compliance issues are defined below:

- Non−compliance with REHS requests to perform bi−annual (or annual) inspections
- Failure to possess, use, and retain a written user logbook including names, dates, and times of use
- Failure to produce an operator's manual and/or written SOP for the unit
- Failure to provide a means to prevent unauthorized use (i.e., unlocked door or keys left in unit)
- Dosimetry badge not worn consistently when operating the unit

Examples of **MAJOR** non−compliance issues are defined below:

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

12.9 X−RAY WORKER RESPONSIBILITIES

An X−ray worker is authorized to work with an RPM under the auspices of an RPM permit, and is responsible for the following:

- Complete X−ray safety training (online) and unit−specific training prior to using the RPM.
- REHS will require dosimetry for the use of RPMs. All workers who utilize RPMs must participate in the dosimetry program. A link to apply for a radiation dosimeter is provided upon completion of the online training noted above.
- Take responsibility for your own safety, and utilize each RPM following manufacturer recommendations.
- Report any abnormal occurrence, such as failure of a safety system or a potential exposure to the primary beam, to the Authoree and REHS immediately.
- Gain approval of the Authoree before making changes to experimental protocols.
- Ensure RPMs are secured from unauthorized use. This typically takes the form of locked rooms or password−protected control consoles.

12.10 POLICY FOR MINORS WORKING IN AUTHORIZED X–RAY LABS

Minors (any person under 18 years of age), including students, full–time employees, part–time employees, and both paid and unpaid 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 near equipment that produces ionizing radiation must not receive a "whole body" dose in excess of 500 mrem per year.

New Jersey labor laws prohibit minors from working directly with radiation–producing machines. However, if the use of an RPM is required as part of an educational degree program, a request for accommodation to use an RPM can be submitted to REHS for consideration. For more information, policies, and responsibilities pertaining to workers who are minors, refer to the section titled ***Volunteers and Minors in the Laboratory*** on the REHS website: https://ipo.rutgers.edu/rehs/minors-lab

✶ Authorees/PIs/Managers must notify REHS if they have or intend to have a minor working in their laboratory that contains any radioactive materials and/or radiation–producing machines ✶

If the minor will work in a lab that has radiation–producing machines but does not operate or work directly with those machines, REHS will perform the following:

- Review the work to be performed by the minor
- Evaluate the laboratory environment to determine any potential for the minor to receive a radiation dose even though they will not work directly with the radiation–producing machine
- Arrange for radiation/X–ray safety training for the minor

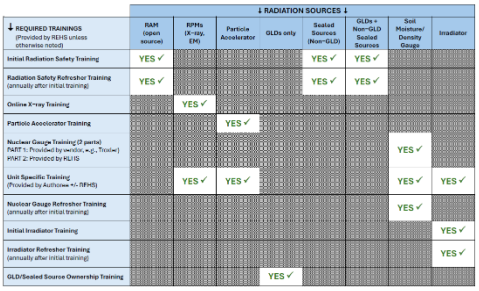
(For information regarding minors working in RAM labs, see *Section 4.8, Policy for Minors Working in Authorized RAM Labs*.)

END OF THE RADIATION–PRODUCING MACHINE SECTION.

13. RADIATION SAFETY TRAININGS

Effective training is an integral part of a safety program. Each individual working with RAM and RPMs 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. Authorees and their radiation workers are required to complete the designated training(s) as listed in the sections below, according to the type of radiation source(s) they will be working with. The following training programs are discussed below (a quick reference training chart per image below is located in the Appendices):

- Radiation Safety Training for open-source RAM work
- RPM Safety Training
- GLD/Sealed Source Ownership Training
- Soil Moisture/Density Gauge Training (e.g., Troxler)
- Irradiator Training



↓ REQUIRED TRAININGS (Provided by REHS unless otherwise noted)	↓ RADIATION SOURCES ↓							
	RAM (open source)	RPMs (X-ray, EM)	Particle Accelerator	GLDs only	Sealed Sources (Non-GLD)	GLDs + Non-GLD Sealed Sources	Soil Moisture/ Density Gauge	Irradiator
Initial Radiation Safety Training	YES ✓				YES ✓	YES ✓		
Radiation Safety Refresher Training (annually after initial training)	YES ✓				YES ✓	YES ✓		
Online X-ray Training		YES ✓						
Particle Accelerator Training			YES ✓					
Nuclear Gauge Training (2 parts) PART 1: Provided by vendor, e.g., Troxler PART 2: Provided by RU-IS							YES ✓	
Unit Specific Training (Provided by Authorees +/- RBHS)		YES ✓	YES ✓				YES ✓	YES ✓
Nuclear Gauge Refresher Training (annually after initial training)							YES ✓	
Initial Irradiator Training								YES ✓
Irradiator Refresher Training (annually after initial training)								YES ✓
GLD/Sealed Source Ownership Training				YES ✓				

In addition to the training courses offered by REHS, individuals who may work with sources of ionizing radiation (RAM, RPM) are encouraged to review the NRC's Regulatory Guide 8.29, Instruction Concerning Risks From Occupational Radiation Exposure.

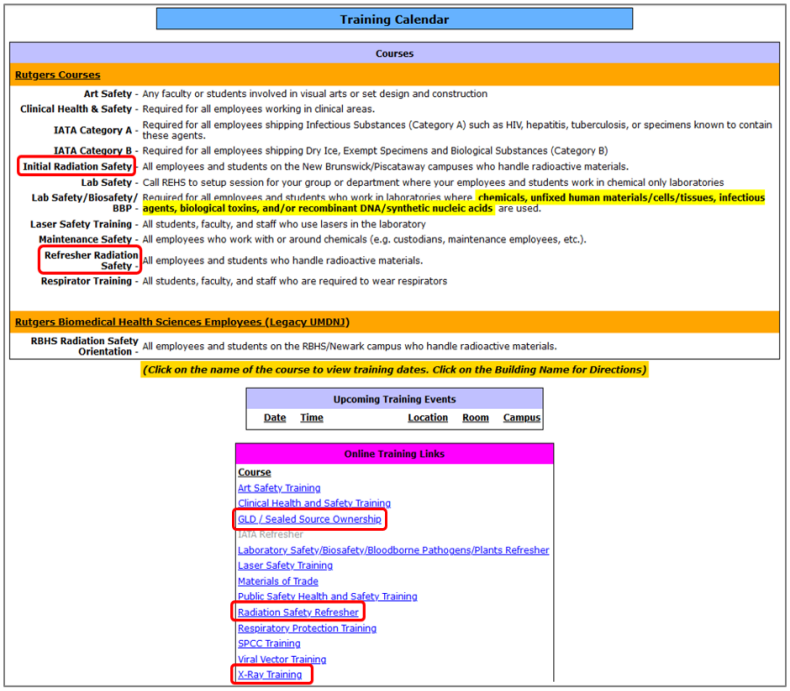
Various safety training courses on radiation sources are provided throughout the year at the University (see sections 13.1 – 13.5). Registration for select radiation safety training courses is available by accessing either of the following Rutgers University websites (both navigate you to the ***Training Calendar***):

- MyREHS website at: https://myrehs.rutgers.edu
- REHS website (*Radiation Safety* page) at: https://ipo.rutgers.edu/rehs/safety/lab/radiation (Under the ***Radiation Training*** section, click on the training option needed.)

Log in with your NetID credentials, then click ***Training Calendar*** button at top of page. The various radiation safety courses are circled in red in the screenshot below.

To view the list of class dates and times for in–person ***Initial Radiation Safety Training***, click on ***Initial Radiation Safety*** in the ***Courses*** box, then scroll down to the next box titled ***Initial Radiation Safety – Upcoming Events*** for the listing.

(**NOTE**: do not choose the *RBHS Radiation Safety Orientation* course - it is designated for personnel working at Rutgers Biomedical Health Sciences (RBHS) on Newark campus.)



Training Calendar

Courses

Rutgers Courses

Art Safety -	Any faculty or students involved in visual arts or set design and construction
Clinical Health & Safety -	Required for all employees working in clinical areas.
IATA Category A -	Required for all employees shipping Infectious Substances (Category A) such as HIV, hepatitis, tuberculosis, or specimens known to contain these agents.
IATA Category B -	Required for all employees shipping Dry Ice, Exempt Specimens and Biological Substances (Category B)
Initial Radiation Safety -	All employees and students on the New Brunswick/Piscataway campuses who handle radioactive materials.
Lab Safety -	Call REHS to setup session for your group or department where your employees and students work in chemical only laboratories
Lab Safety/Biosafety/ BBP -	Required for all employees and students who work in laboratories where **chemicals, unfixed human materials/cells/tissues, infectious agents, biological toxins, and/or recombinant DNA/synthetic nucleic acids** are used.
Laser Safety Training -	All students, faculty, and staff who use lasers in the laboratory
Maintenance Safety -	All employees who work with or around chemicals (e.g. custodians, maintenance employees, etc.).
Refresher Radiation Safety -	All employees and students who handle radioactive materials.
Respirator Training -	All students, faculty, and staff who are required to wear respirators

Rutgers Biomedical Health Sciences Employees (Legacy UMDNJ)

RBHS Radiation Safety Orientation -	All employees and students on the RBHS/Newark campus who handle radioactive materials.

(Click on the name of the course to view training dates. Click on the Building Name for Directions)

Upcoming Training Events

Date	Time	Location	Room	Campus

Online Training Links

Course

Art Safety Training
Clinical Health and Safety Training
GLD / Sealed Source Ownership
IATA Refresher
Laboratory Safety/Biosafety/Bloodborne Pathogens/Plants Refresher
Laser Safety Training
Materials of Trade
Public Safety Health and Safety Training
Radiation Safety Refresher
Respiratory Protection Training
SPCC Training
Viral Vector Training
X-Ray Training

13.1 RAM SAFETY TRAINING

INITIAL TRAINING

Prior to beginning work with RAM, prospective Authorees and radiation workers must complete an in−person initial radiation safety orientation, which is provided at the REHS office on the Livingston campus (74 Street 1603, Building 4115).

REQUIRED TRAINING	INFORMATION
REHS Course: ***Initial Radiation Safety Training*** ***(In-person only)***	This training covers the basics of radiation science, interactions with matter, safe handling procedures, methods to reduce internal and external radiation exposure, emergency procedures, radiation dosimetry, survey requirements, etc. An examination is administered to ensure attendees have mastered the concepts, and a passing grade of 80% is required.

Upon successful completion of initial training:

- The trainee will be added as a radiation worker to the Authoree's RAM permit.
- If the Authoree/radiation worker meets the dosimetry requirements outlined in *Section 14.2-A, Dosimetry-Regulations* and *University Policies*, they will be directed to submit a radiation dosimetry application online to REHS via the *Dosimeter Badge/Ring Application* on the REHS website here: https://halflife.rutgers.edu/forms/radbadge.php

  For more information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

NOTE: The Radiation Safety Group recognizes there may be unique occasions in which a lab employee or visiting scientist needs to work with RAM but has either received radiation safety training at a different institution or is unable to wait for the next scheduled initial radiation safety training session. Contact the Radiation Safety Group at radgroup@ipo.rutgers.edu to discuss the situation and consideration of either a training exemption or a dedicated training session.

REFRESHER TRAINING

Following successful completion of initial radiation safety training, all Authorees and radiation workers must complete online refresher training **annually (each calendar year) thereafter**:

TRAINING	INFORMATION
REHS Course: ***Refresher Radiation Safety Training*** ***(Online)***	This training covers an abbreviated amount of the initial radiation safety training course, and is available online or in person (upon request).

Failure to satisfy annual refresher training requirements may result in an NOV and suspension of RAM delivery until the training requirement is satisfied. If there is a training lapse of 3 years or more, the worker must attend in−person initial radiation safety training.

If a lab receives a major NOV, the Authoree and their radiation workers may be required to attend in−person refresher training in lieu of taking the online training module.

13.2 RPM SAFETY TRAINING

X–RAY & EM USERS

INITIAL TRAINING

Prior to operating any radiation–producing machine, the Authoree and their authorized X–ray users will be required to successfully complete the 2 trainings in the table below. X–ray training is required for all users of RPMs, not just X–ray users, such as electron microscopes, ion mills, etc.

TRAINING	INFORMATION
REHS Course: ***Online X–ray Training***	This training covers the basics of radiation science, interactions with matter, safe handling procedures, methods to reduce external radiation exposure, emergency procedures, radiation dosimetry, etc. Examination questions are administered to ensure attendees have mastered the concepts, and a passing grade of 80% is required. This course is accessible here (*Radiation Training* section): https://ipo.rutgers.edu/rehs/safety/lab/radiation
Unit–Specific Training	The Authoree or their designee must provide in–person, unit–specific training for each user.

Upon successful completion of this training:

- The trainee will be added as an X–ray worker to the Authoree's X–ray permit.
- The Authoree/X–ray worker must submit a radiation dosimetry application online to REHS via either the link that is provided at the end of the course OR the *Dosimeter Badge/Ring Application* on the REHS website here: https://halflife.rutgers.edu/forms/radbadge.php

  For more information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

For more information and a listing of RPM types, refer to *Section 12, Radiation–Producing Machines*.

REFRESHER TRAINING

Refresher training is not required for X–ray workers. However, to enable workers using RPMs to refresh and update their knowledge about X–ray safety, regulations, University policies, and operations, REHS will provide an educational bulletin that contains useful information and updates on X–ray safety. These bulletins will be posted in each RPM lab for review and updated at the discretion of the RSO with a programmatic goal of reviewing and updating the bulletin every 2 years.

PARTICLE ACCELERATOR USERS

INITIAL TRAINING

Currently, there are 2 machines in the physics department located on Busch campus that qualify as particle accelerators (PA) per NJDEP requirements. These 2 units have training requirements distinct from the rest of the RPMs located on campus. Individuals who wish to use either of these particle accelerators without supervision must be designated as qualified machine operators (QMO) by the Particle Accelerator Safety Officer (PASO). Particle accelerator users must also complete the training requirements in the table below.

TRAINING	INFORMATION
REHS Course: ***Particle Accelerator Training*** ***(In-person only)***	This training covers the basics of radiation science, interactions with matter, safe handling procedures, methods to reduce external radiation exposure, emergency procedures, radiation dosimetry, etc. In addition, it covers the particle accelerator-specific safety requirements governed by N.J.A.C. 7:28-20.6. Examination questions are administered to ensure attendees have mastered the concepts, and a passing grade of 80% is required. This is an in−person training provided by REHS upon request.
Unit−Specific Training	A QMO must provide in−person unit−specific training for each new user.

Upon successful completion of this training:

- The trainee will be added as a worker to the particle accelerator Authoree's permit.
- The new worker must submit a radiation dosimetry application online via the *Dosimeter Badge/Ring Application* on the REHS website here: https://halflife.rutgers.edu/forms/radbadge.php

  For more information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

REFRESHER TRAINING

Refresher training is required for particle accelerator users every 3 years. The PASO, in conjunction with the particle accelerator users and the RSO, coordinates in−person refresher training.

13.3 SEALED SOURCE & GLD SAFETY TRAINING

INITIAL TRAINING

Prior to beginning work with sealed sources, prospective Authorees and radiation workers must complete one of the following trainings. Contact REHS at radgroup@ipo.rutgers.edu or 848-445-2550 if there are any questions as to which training is appropriate for your use of sealed sources.

TRAINING	WHO TAKES COURSE?	INFORMATION
REHS Course: ***Initial Radiation Safety Training*** ***(In-person only)***	Individuals working with specifically licensed sealed sources	This training covers the basics of radiation science, interactions with matter, safe handling procedures, methods to reduce internal and external radiation exposure, emergency procedures, radiation dosimetry, survey requirements, etc. At the conclusion of this training, an examination is administered to ensure attendees have mastered the concepts, and a passing grade of 80% is required.
REHS Course: ***GLD/Sealed Source Ownership*** ***(Online)***	Individuals working exclusively with GLDs (the lab does not have a RAM permit assigned by the University RSC)	This training covers the responsibilities labs have as custodians of GLDs. Typical examples of GLDs include gas chromatographs with electron capture detectors (Ni−63), aerosol and/or particle counters (Kr−85), self−luminous exit signs (H−3), and some isotopic−based x−ray fluorescence units (Cd−109 and Am−241). The training class is offered online.

Upon successful completion of initial training:

- The trainee will be added as a radiation worker to the Authoree's RAM permit.
- If the Authoree/radiation worker meets the dosimetry requirements outlined in *Section 14.2-A, Dosimetry-Regulations and University Policies*, they will be directed to submit a radiation dosimetry application online to REHS via the *Dosimeter Badge/Ring Application* on the REHS website here: https://halflife.rutgers.edu/forms/radbadge.php

  For more information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

REFRESHER TRAINING

Following successful completion of initial radiation safety training, refresher training may be required.

TRAINING	WHO TAKES COURSE?	INFORMATION
REHS Course: ***Refresher Radiation Safety Training*** ***(Online)***	Individuals working with specifically licensed sealed sources	This training is available online or in person (upon request). All Authorees and radiation workers must complete online refresher training **annually (each calendar year) following initial radiation safety training**. Failure to satisfy annual refresher training requirements may result in an NOV and suspension of RAM delivery until the training requirement is satisfied. If there is a training lapse of 3 years or more, the worker must attend in−person initial radiation safety training. If a lab receives a major NOV, the Authoree and their radiation workers may be required to attend in−person refresher training in lieu of taking the online training module.
REHS Course: ***GLD/Sealed Source Ownership*** ***(Online)***	Individuals working exclusively with GLDs	Refresher training is not required for those who own and/or work with GLDs; however, the Authoree and/or RSO may require refresher training following instances of non−compliance. This training class is available online.

13.4 SOIL MOISTURE/DENSITY GAUGE (TROXLER) TRAINING

INITIAL TRAINING

Prior to beginning work with a Troxler unit, prospective Authorees and radiation workers must complete all of the following:

TRAINING	INFORMATION
REHS Course: ***Nuclear Gauges Safety Training*** ***(In-person only)***	This training is provided by REHS and is only available in person upon request.

Vendor Training by Troxler	The Authoree/department is responsible for ensuring prospective gauge users successfully complete this training and provide proof of training (certificate of completion) to REHS. Any costs for this training must be borne by the Authoree/department. The RSC will not consider approving new gauge users who have not completed this vendor training. The appropriate course can be found on the Troxler website as of April 2025 (https://troxlerlabs.com/training/).	**Nuclear Gauge Operator Safety Training Course plus Hazmat** This course is for nuclear moisture density gauge operators. This course provides the certification required to operate and transport nuclear moisture density gauges. A quiz will be given at the end, and a certificate will be issued with a passing score.
Unit–Specific Training	The Authoree or designee is required to provide in–person, unit–specific training for each user.	

Upon successful completion of the Troxler and unit-specific training:

- The trainee will be added as a radiation worker to the Authoree's RAM permit.
- The Authoree/radiation worker must submit a radiation dosimetry application online to REHS via the *Dosimeter Badge/Ring Application* on the REHS website here:

  https://halflife.rutgers.edu/forms/radbadge.php

  For more information on dosimetry, see *Section 14, Radiation Monitoring of Personnel*.

REFRESHER TRAINING

Following successful completion of initial training, all Authorees and radiation workers must complete the following in-person refresher training **annually (each calendar year) thereafter**:

TRAINING	INFORMATION
REHS Course: ***Nuclear Gauges Safety Training*** ***(In-person only)***	This training is provided by REHS and is only available in person upon request.

13.5 IRRADIATOR SAFETY TRAINING

The University has several self–shielded irradiators available for irradiation of (typically) cell lines and rodents. Anyone interested in utilizing these irradiators should contact the REHS Radiation Safety Group at radgroup@ipo.rutgers.edu or 848-445-2550. The RSO or their designee will assist you, as the self–shielded irradiators are subject to additional regulatory requirements above and beyond those discussed in this guide. For approved users, training will consist of the following: online training via PowerPoint with quiz, in–person, irradiator–specific training, and annual online refresher training.

14. RADIATION MONITORING OF PERSONNEL

14.1 OCCUPATIONAL EXPOSURE LIMITS

Occupational radiation exposure limits have been established by the NRC and adopted by the NJDEP. In alignment with the principle of ALARA (***A**s **L**ow **A**s **R**easonably **A**chievable*), REHS has set lower radiation exposure guidelines that are 10% of the NJDEP regulatory limits. It is the responsibility of each individual to keep their radiation exposure ALARA, aim to stay below the REHS guideline levels when possible, and avoid exposure to radiation when exposures are unnecessary.

TARGET TISSUE	NJDEP REGULATORY LIMITS	ALARA/REHS GUIDELINES (10% of Regulatory Limit)
Whole Body	**5,000 mrem/YEAR**	**125 mrem/QUARTER**
Lens of Eye	**15,000 mrem/YEAR**	**375 mrem/QUARTER**
Skin & Bodily Extremities ("shallow dose;" arms below elbows, hands, legs below knee, feet, etc.)	**50,000 mrem/YEAR**	**1,250 mrem/QUARTER**
Embryo/Fetus	**500 mrem/gestational period (of 9–10 months)**	**50 mrem/month of gestation**

REHS will investigate any radiation exposure exceeding:

- 125 mrem (whole body) or 1,250 mrem (shallow dose or extremity) per quarterly wear period. These doses represent 10% of the annual occupational dose limit divided by 4, as there are 4 quarterly dosimeter wear periods per year.
- 50 mrem during any month of a pregnancy.

14.2 DOSIMETRY

Radiation dosimetry is the measurement of external ionizing radiation absorbed by the body. Dosimeters, such as a ring or whole body badge, passively record the radiation dose they receive. *Personal dosimeters* are worn on the worker's body (torso, finger, and/or wrist); therefore, they must be worn appropriately to accurately represent the worker's occupational radiation exposure. *Area monitoring dosimeters* are placed at designated locations to monitor radiation levels at one location 24/7/365.

REHS must provide dosimetry to employees who work with radioactive materials (including sealed sources) such that this work has the potential to deliver an ionizing radiation dose in excess of 10% of any regulatory dose limit. In addition to this dose-based criteria, NJDEP's regulations require that most users of radiation-producing machines require some form of dosimetry.

As a best management practice, REHS provides dosimetry to employees who have a reasonable chance of receiving any measurable occupational exposure to radiation.

A. REGULATIONS AND UNIVERSITY POLICIES

The University shall monitor exposures to radiation emitted by RAM and radiation−producing machines at levels sufficient to demonstrate compliance with the NRC's occupational dose limits as specified by 10 CFR Part 20 and referenced by the NJDEP in N.J.A.C. 7:28.

As required by the NRC/NJDEP and/or University policy, the University shall monitor occupational exposures to radiation as well as supply and require the use of individual radiation monitoring badges to the following individuals:

- Adults likely to receive a dose in excess of 10% of the exposure limits from sources external to the body on an annual basis.
- As defined by the NRC/NJDEP, individuals entering an area designated as a:
    - ***Radiation Area***: an area where radiation levels could result in an individual receiving a dose in excess of 5 mrem/hour. *(Probability at Rutgers = Possible)*
    - ***High Radiation Area***: an area where radiation levels could result in an individual receiving a dose in excess of 100 mrem/hour. *(Probability at Rutgers = Possible but unlikely)*
    - ***Very High Radiation Area***: an area where radiation levels could result in an individual receiving a dose in excess of 500,000 mrem/hour. (*Probability at Rutgers = Not possible)*
- Most individuals who use radiation−producing machines
- Declared pregnant workers
- Minors (people under 18 years of age) working in a lab that utilizes RAM and/or RPMs (NOTE: refer to *Sections 4.8, 12.10, and 14.5* for more info)

This policy precludes most university personnel from needing dosimetry, including those working with generally licensed materials. The RSO will determine who requires monitoring on a case−by−case basis. The following list includes but is not limited to typical examples of activities that require dosimetry:

- Radioiodination procedures using I−125 or I−131
- Experiments utilizing at least 1 millicurie (mCi) of P−32 (e.g., cell labeling)
- Use of radiation−producing machines such as the following:
    - Analytical, medical, and analytical X−ray
    - Cabinet X−ray
    - Hand−held X−ray units
    - Bone densitometer
    - Particle accelerators
    - PET−CT
    - Electron microscopes (dosimetry is issued for only the first year of each unit's operation)
- Benchtop use of gamma−emitting nuclides
- Pregnant workers who (a) work directly with radioactive materials and/or radiation−producing machines or (b) are concerned because they work in a radioactive materials lab

The most common radioisotopes used on the benchtop at Rutgers do not require employees to wear radiation dosimeters. Radionuclides having low to moderate beta energies, such as H−3, C−14, and S−35, are unable to deliver a whole body "deep" dose; therefore, the use of whole body dosimetry is unwarranted. However, care must still be taken to ensure no radiation is deposited internally (ingested, inhaled, or injected) or onto 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 involving skin contamination.

B. TYPES OF DOSIMETERS

REHS will determine which dosimeters employees will need based on the information provided in the dosimetry application and/or discussions with the employee and/or Authoree. The dosimetry application can be found on the REHS website here: https://halflife.rutgers.edu/forms/radbadge.php

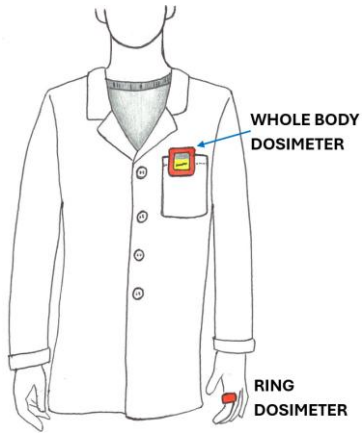
The main types of dosimeters used at the University are whole body badges and ring or wrist dosimeters.

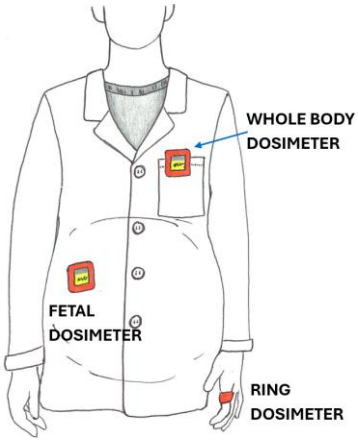
Whole body badges provide an indication of the maximum dose received by the trunk of the body.

- *Energy Response*: gamma, X−ray, and high energy beta radiation
- *Wear Location*: worn at front of body between neck and waist with the label facing outwards. Exceptions include:
  - *Fetal badges*: worn at the front of the waist (closest to the embryo/fetus) with the label facing outwards
  - *Workers who work around medical X−ray units*: worn at front of body between neck and waist with the label facing outwards and outside of lead apron or thyroid shield

Ring or wrist dosimeters provide an indication of the maximum dose received by the hands and/or forearms.

- *Energy Response*: gamma, X−ray, and high energy beta radiation
- *Wear Location*: on the hand that is most frequently closest to the radiation source. Ensure the name plate label (it covers the lithium fluoride [LiF] chip) is facing the radiation source. When gloves are worn, wear the ring under the gloves.





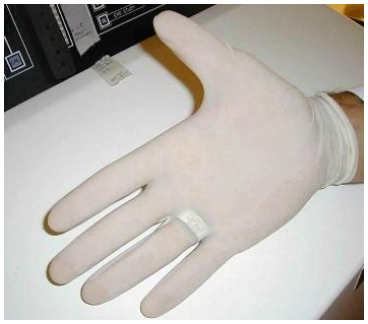


Figure 10: Dosimeter wear locations.

C. DOSIMETER PROCESSING

After each designated wear period, REHS will exchange the worker's used dosimeter(s) with a new batch. Most dosimeters are exchanged during the first week of every calendar quarter (January, April, July, October); fetal badges are exchanged during the first week of every month. The used dosimeters are then mailed to the vendor where the captured doses can be processed for that wear period to generate a radiation exposure report for each worker. It takes approximately four to six weeks to have used dosimeters exchanged and then mailed to and processed by the dosimetry vendor. The dosimeters used at the University do not provide immediate feedback for real−time doses.

If an individual's dose exceeds the University's internal ALARA limits (10% of the NJDEP's limits), the RSO or their associate 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 neither a violation nor implies that work practices are inappropriate.

D. DOSIMETER RULES

A complete list of *Dosimetry Rules and Limitations* for research staff is available on the REHS radiation safety website and in the *Appendices* of this guide.

- ALWAYS wear your ring dosimeter (and fetal badge, if pregnant) with the label facing the radiation source when working with a radiation source.
- Care should be taken to ensure that dosimeters are not contaminated with RAM.
- Notify REHS if your dosimeter is lost so that REHS can issue a replacement to you as soon as possible.
- Don't share your dosimeter with anyone else…your dosimeter is assigned to you only.
- Don't deliberately expose your dosimeter to radiation or place them inside X−ray units.
- Store your dosimeter at a safe distance from a radiation source where radiation levels are consistent with background, and either in the lab or a designated area when not in use.
- Don't expose the dosimeter to sun or heat since sun/heat can yield inaccurately elevated radiation doses or erase any recorded exposures.
- Don't wear your dosimeter during personal medical tests (e.g., medical X−rays, dentistry appointments, nuclear medicine procedures, etc.).
- Ensure your dosimeter(s) is available for exchange during the first week of every calendar quarter (January, April, July, October). For fetal badges, ensure your badge dosimeter is available for exchange at the beginning of every month.
- Notify REHS when you no longer require a dosimeter or leave the University.

E. EXPOSURE REPORTS AND RECORDS

Radiation dosimeters provide legal documentation of external radiation exposure received while working with RAM and/or radiation−producing machines. All dosimetry records and occupational exposure reports are maintained at REHS. On an annual basis, REHS will distribute a "*Form 5 – Occupational Exposure Record for a Monitoring Period*" to any individual who received a detectable dose above 100 mrem over the course of the previous calendar year. However, since approximately 95% of the radiation workers at the University to whom REHS has issued a dosimeter have non−detectable (ND) doses by the dosimeter, a majority of radiation workers will not receive a *Form 5*.

Individuals may contact REHS at any time to request a copy of their radiation exposure records (email radgroup@ipo.rutgers.edu or call 848−445−2550).

14.3 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. The embryo or fetus is more sensitive to radiation than the adult, especially during the first trimester of pregnancy. This can be a concern since many pregnant individuals are unaware of their pregnancy during the first 1−2 months of gestation. Hence, the NJDEP requires that all occupationally exposed workers be instructed on the potential health risks associated with prenatal radiation exposure.

As defined by the NRC (10 CFR 20.1003) and NJDEP (N.J.A.C. 7:28): *"Declared pregnant woman means a woman who has voluntarily informed the licensee or registrant, in writing [emphasis added], of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant*."

A pregnant worker may elect to consult with a member of REHS to assess their potential radiation exposure and discuss measures to keep their exposures ALARA. A radiation worker who is or becomes pregnant is advised to declare their pregnancy in writing to REHS. **Early declaration of a pregnancy is encouraged, and confidentiality is always maintained**. The *Declaration of Pregnancy/Fetal Badge Application* form is available on the REHS radiation safety website and in the *Appendices* of this guide. Once the form is completed, the worker can email, fax, or mail it to REHS. Once the declaration is made, REHS will issue a fetal badge to the pregnant worker, and the prenatal exposure limits take effect. The pregnant worker should also read the NRC's Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure (also included in the *Appendices* of this guide).

The maximum permissible radiation exposure to the fetus of a declared pregnant worker during the gestation period is **500 mrem** (which is 10% of the NJDEP's annual whole body dose limit of 5,000 mrem). An effort should be made to **maintain monthly doses below 50 mrem** 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 (a) 50 mrem/month or (b) 500 mrem over 10 months.

If notification of a pregnancy is not declared in writing by the worker, the radiation exposure limit remains at the annual occupational limit (whole body) of 5,000 mrem.

14.4 EXPOSURE LIMITS FOR THE GENERAL PUBLIC

Visitors to a radiation laboratory are considered members of the general public when they are:

- not classified as occupational radiation workers by the University
- laboratory workers who are not trained in radiation safety (non−radiation workers)
- custodial and maintenance staff
- guests and vendors who are not affiliated with the University

In accordance with the NRC (10 CFR 20.1301) and NJDEP (N.J.A.C. 7:28), members of the general public shall not receive a radiation dose from external sources in excess of:

- 100 mrem in any one year

  OR

- 2 mrem in any one hour

This can be achieved in the laboratory by appropriately storing RAM, performing post−experiment surveys, labeling all radiation sources and instruments, using appropriate shielding, cleaning up spills promptly, and educating visitors when they enter the lab.

Prior approval by REHS is needed when planning the following:

- Radioiodinations
- Use of the gaseous form of any radioactive compound
- Use of all other non−iodine, volatile radioactive compounds

14.5 EXPOSURE LIMITS FOR MINORS

In accordance with the NRC (10 CFR 20.1207) and NJDEP (N.J.A.C. 7:28), the annual occupational dose limits for minors (students and employees who are under 18 years of age) are 10% of the annual dose limits specified for adult workers by the NRC (10 CFR 20.1201). Therefore, **minors working in RAM and/or X−ray labs cannot exceed a whole body dose of 500 mrem in any one year**.

IMPORTANT NOTE: Please contact REHS if minors will be working or volunteering in labs authorized for RAM and/or RPM use. Notwithstanding the dose limit restrictions noted above, the underlying reason for the minor to work in these labs will inform what activities REHS may authorize. New Jersey's Child Labor Law makes a distinction between work and/or volunteer activities vs. work directly related to an educational degree program. For more details, refer to either *Section 4.8, Policy for Minors Working in Authorized RAM Labs,* or *Section 12.10, Policy for Minors Working in Authorized X−ray Labs*. It is crucial for Authorees or supervisors to contact REHS prior to any minors starting work in RAM and/or RPM labs.

14.6 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 radioiodinations (typically using I−125 or I−131) are required to complete both of the following:
    - Obtain a baseline thyroid bioassay prior to their first radioiodination
    - Obtain a thyroid bioassay 24−72 hours following each radioiodination
- Individuals handling greater than 100 mCi of H−3 must submit a urine sample to REHS for bioassay testing within 24 hours of handling H−3. This bioassay must be performed each time 100 mCi or greater of H−3 is handled.
- In the event of a radioactive spill, release, or contamination incident, REHS may require further bioassays from affected individuals.
- At the discretion of the RSO.

15. DEFINITIONS

Activity

The rate of disintegration ("decay") at which radioactive material emits radiation, expressed per unit of time (dpm = disintegrations per minute; dps = disintegrations per second). The units of activity are:

- Becquerel (Bq) = International System of Units (SI) [1 Bq = 1 dps]
- Curie (Ci) = Special Unit [3.7×10^{10} dps or 2.22×10^{12} dpm]

In 1960, the SI system (International System of Units; also known as the metric system) was established to standardize units of measure. Prior to the SI system, the United States utilized special units for radioactivity, such as the Curie. Since the development of the SI system, the U.S. has predominantly continued to use special units of measure despite a majority of the world switching to the SI system.

ALARA

A guiding principle of radiation protection to maintain exposures to ionizing radiation as far below the dose limits as practical ("**A**s **L**ow **A**s **R**easonably **A**chievable") and consistent with the purpose for which the licensed activity is undertaken. ALARA utilizes three (3) protective measures in radiation safety: time, distance, and shielding.

Alpha Particles

Alpha particles (α) consist of two (2) protons and two (2) neutrons bound together (identical to a naked helium nucleus). They can travel a few inches in the air and rarely penetrate the outer dead layer of skin due to their higher mass and greater electrical charge than beta particles. Alpha emitters are typically not an external radiation hazard.

Authoree

A Principal Investigator who is authorized by the Radiation Safety Committee to possess and use radioactive materials.

Beta Particles

A charged particle that is emitted from the nucleus of a radioactive element during radioactive decay (or disintegration) of an unstable atom. A negatively charged beta particle is identical to an electron, while a positively charged beta particle is called a positron. Most beta particles (β) do not normally penetrate beyond the skin, but when sufficiently intense, can cause skin and/or eye damage.

Bioassay

Bioassay measurements include the analysis of radioactive material in body organs or in the whole body (in vivo measurements) and in biological material excreted, eliminated, or otherwise removed from the body (in vitro measurements). Bioassays may be used to confirm the proper functioning of a radiation protection program or to quantify a suspected intake of radioactive material.

Biohazard

A substance that threatens the health of living organisms, and includes biological agents, biotoxins, human blood & blood products, contaminated sharps, animal waste and products, some organic matter, etc.

Chemiluminescence

The emission of light (electromagnetic radiation; luminescence) during the course of a chemical reaction.

Controlled Area

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

Counts Per Minute (cpm)

A measurement of ionizing radiation expressed as the rate of detection by the radiation measuring instrument.

Disintegrations Per Minute (dpm)

A measure of radioactivity expressed as the rate of atomic disintegration events at a radiation source. The counting efficiency of the radiation detector is also accounted for in determining the dpm.

Dosimetry

Radiation dosimetry is the measurement of external ionizing radiation absorbed by the body. Dosimeters, such as a ring or whole body badge, record the radiation dose they receive.

Exposure

Absorption of ionizing radiation or the amount of a hazardous substance that has been ingested, inhaled, or in contact with the skin. Acute exposure occurs over a short period of time. Chronic exposure is received over a long period of time, such as during a lifetime. With respect to ionizing radiation, exposure is expressed as energy deposited per unit mass.

Gamma Rays

Gamma rays (γ) are a high-energy, short wavelength form of electromagnetic radiation that is very penetrating and is sometimes emitted by the nuclei of atoms during radioactive decay. Gamma rays and X−rays are essentially equivalent to each other. Gamma rays originate in the nucleus of a radioactive atom, whereas X−rays originate outside of the nucleus.

General License

A subset of RAM (materials such as uranium or thorium-containing compounds) or devices/instruments containing radioactive sources (e.g., liquid scintillation counters, gas chromatographs with electron capture devices, etc.) may be purchased by any company/institution under a general license and without the need for a specific license. Although no specific license is required, those who possess generally licensed materials or instruments must keep proper inventories, utilize the devices as instructed by the manufacturer, maintain appropriate security, and dispose of the materials properly.

Generally Licensed Device (GLD)

Usually consists of radioactive material contained as a sealed source within a shielded device. GLDs have safety features engineered into the design, and direct handling of the radiation source is very difficult under normal operating conditions.

Generally Licensed Source Material (GLSM)

Compounds or chemicals that contain uranium (U) or thorium (Th) in their natural isotopic concentrations and are possessed and used in small quantities per 10 CFR Part 40.22.

Inventory Verification Report (IVR)

Lists all transactions involving radioactive materials that took place during a period of time (typically, the previous 6 months). It includes all isotope deliveries, waste removals, transfers, and correction of data entry errors, if necessary.

Ionizing Radiation

A form of radiation, which includes alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. When ionizing radiation passes through material such as air, water, or living tissue, it deposits enough energy to produce ions by breaking molecular bonds and displace (or remove) electrons from atoms or molecules.

Inverse Square Rule

As pertains to electromagnetic radiation exposure (gamma rays and X−rays), a principle that the "intensity" of radiation emitted from a source of radiation is inversely proportional to the square of the distance from that source.

Example: an object (of the same size) twice as far away receives only one-quarter the energy (in the same time period).

LD_{50} (lethal dose)

The amount of a toxic agent (such as a poison, virus, or radiation) that is sufficient to kill 50 percent of a population of test animals within a certain time.

Minimum Detectable Activity (MDA)

The minimum detectable (quantifiable) activity in dpm that is detectable by the specific system for that measurement at a specified degree of confidence.

Non-Ionizing Radiation

A type of electromagnetic radiation that lacks enough energy to remove electrons from atoms or molecules, thus, preventing them from becoming ions.

Personal Protective Equipment (PPE)

Clothing and equipment that the worker wears to minimize exposure to hazards that may cause workplace injuries and/or illnesses.

Principal Investigator (PI)

The lead researcher (typically a faculty member or equivalent at the University) on a research project who is responsible for its overall conduct, oversight, and ensuring compliance with federal/state regulations and University policies. PIs authorized by the University to possess and use radioactive material are called Authorees.

Radiation Areas

- ***Radiation Area***: an area where radiation levels could result in an individual receiving a dose in excess of 5 mrem/hour. (Probability at Rutgers = Possible)
- ***High Radiation Area***: an area where radiation levels could result in an individual receiving a dose in excess of 100 mrem/hour. (Probability at Rutgers = Possible but unlikely)
- ***Very High Radiation Area***: an area where radiation levels could result in an individual receiving a dose in excess of 500,000 mrem/hour. (Probability at Rutgers = Not possible)

Radiation–Producing Machine (RPM)

A device that produces and emits ionizing radiation (typically, X–rays) and is loosely categorized as analytic, diagnostic, or therapeutic.

Radioactive Contamination

When RAM is in an unwanted or unplanned location, such as on floors, work areas, equipment, people/clothing, or areas outside the authorized laboratory.

Radioactive Decay

The process by which an unstable atomic nucleus loses energy by emitting radiation.

Radioactive Material (Radionuclide)

An unstable form of a chemical element or atom (nuclear material and other radioactive substances) that undergoes spontaneous disintegration, then releases radiation as it decays and becomes more stable.

Radioactive Waste

Any waste that is contaminated with or contains radioactive material.

Roentgen (R)

A legacy unit of measurement for the exposure of X-rays and gamma rays; defined as the electric charge freed by X-ray or gamma radiation in a specified volume of air at standard temperature & pressure (STP).

Roentgen Equivalent Man (rem)

A legacy unit used to measure dose equivalent (or effective dose), which combines the absorbed dose with the biological effects of different types of radiation on human tissue.

Sealed Radioactive Source ("sealed source;" SS)

Radioactive material that is encased in a capsule designed to prevent the source from escaping or being released under normal conditions.

Sharps

Items with sharp points or cutting edges that are capable of causing injury to a worker handling the item, and may be contaminated with a hazard (chemical, biological, RAM, etc.). Examples include needles, syringes, scalpel/razor blades, etc.

Shielding

The use of materials (e.g., plexiglass, lead, concrete, water, etc.) to absorb or attenuate the amount of radiation reaching a specific area or person, protecting against its harmful effects.

Specific License

The radioactive material license, issued by the NJDEP's Bureau of Environmental Radiation (BER), that empowers the University to manage the purchasing, use, storage, and disposal of nearly all radioactive materials used to support its teaching and research mission.

Survey Meter

A portable, handheld electronic instrument that is used to detect and measure ionizing radiation. It is used to check the environment, personnel, and equipment for radioactive contamination and background radiation. A survey meter consists of three (3) elements:

- A probe that detects radiation
- Electronics (within a meter body) to process the signal
- A display or speaker to indicate the radiation level to the user

X−rays

X−rays are a high-energy, short wavelength form of electromagnetic radiation that are produced when fast-moving charged particles (typically, electrons) collide with a solid target, like a metal plate. X−rays and gamma rays are essentially equivalent to each other. Gamma rays originate in the nucleus of a radioactive atom, whereas X−rays originate outside of the nucleus.

APPENDICES

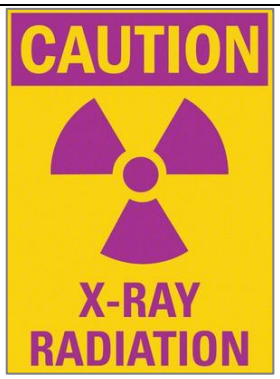
CHARACTERISTICS OF COMMON RADIONUCLIDES (RN)

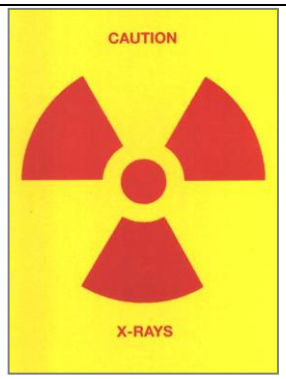
RN	Emission	Energy Max (KeV)	Γ (R-cm²/mCi-hr)	Half-life	Shielding	Instruments	
						Portable	Fixed
C-14	Beta minus	156	NA	5730 years	None	GM ~ 2%	LSC
H-3	Beta minus	18.6	NA	12.3 years	None	NA	LSC
S-35	Beta minus	167	NA	87.4 days	None	GM ~ 2%	LSC
P-33	Beta minus	249	NA	25.4 days	None	GM ~ 2%	LSC
P-32	Beta minus	1710	NA	14.3 days	Lucite	GM ~ 20%	LSC
Ca-45	Beta minus	256.9	NA	162.7 days	None	GM ~ 2%	LSC
I-125	Gamma X-ray gamma	35 keV (6%) 27 keV (112%) 35 keV (10%)	1.6	60.14 days	Lead	NaI ~ 8%	LSC Gamma
Cr-51	Gamma X-ray gamma	320 keV (10%) 4 keV (67%) 5 keV (20%)	0.18	27.7 days	Lead	GM ~ 2% NaI ~ 2%	LSC Gamma

RN	Beta Range in Air (cm)	Beta Range in Water (cm)	Dosimetry	ALI Ingestion µCi	ALI Inhalation µCi	Beta Dose rate to skin from 1 µCi over distributed over 1 cm²
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

COMMON POSTINGS: SIGNS AND LABELS

A "CAUTION: RADIOACTIVE MATERIALS" sign is posted on doors leading into RAM labs. This sign may also be affixed to a fume hood or equipment that may be contaminated.



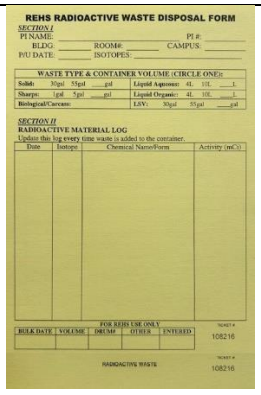


A "CAUTION: X-RAYS" sign is posted on doors leading into labs that house radiation producing equipment.

An "INACTIVE RADIOACTIVE MATERIAL LOCATION" sign is posted on doors leading into labs that have been deactivated for RAM 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 label is affixed to all radiation producing equipment.

A radioactive source label is affixed to equipment containing radioactive sources, such as liquid scintillation counters, gas chromatographs (with ECD's), etc.



Radioactive Waste Disposal Form
("Yellow Waste Cards")
This form is used to document radioactive waste and is provided to REHS at the time of waste pick-up.

REQUIRED TRAININGS TO WORK WITH RADIATION SOURCES

	↓ RADIATION SOURCES ↓							
↓ REQUIRED TRAININGS (Provided by REHS unless otherwise noted)	**RAM (open source)**	**RPMs (X–ray, EM)**	**Particle Accelerator**	**GLDs only**	**Sealed Sources (Non–GLD)**	**GLDs + Non–GLD Sealed Sources**	**Soil Moisture/ Density Gauge**	**Irradiator**
Initial Radiation Safety Training	YES ✓				YES ✓	YES ✓		
Radiation Safety Refresher Training (annually after initial training)	YES ✓				YES ✓	YES ✓		
Online X–ray Training		YES ✓						
Particle Accelerator Training			YES ✓					
Nuclear Gauge Training (2 parts) PART 1: Provided by vendor, e.g., Troxler) PART 2: Provided by REHS							YES ✓	
Unit Specific Training (Provided by Authoree +/- REHS)		YES ✓	YES ✓				YES ✓	YES ✓
Nuclear Gauge Refresher Training (annually after initial training)							YES ✓	
Initial Irradiator Training								YES ✓
Irradiator Refresher Training (annually after initial training)								YES ✓
GLD/Sealed Source Ownership Training				YES ✓				

LIQUID SCINTILLATION & FLOW FLUIDS

Below is a list of REHS-approved scintillation and flow fluids that are safe and non-hazardous. REHS' criteria for approval includes but is not limited to a flashpoint greater than 140 °F, a pH range between 4 and 10, and no other hazardous constituents in the fluid.

If you wish to use a scintillation fluid that is not on this list or have any questions regarding this list, please contact the REHS Radioactive Waste Group: (848) 445-2550 or hazwaste@rutgers.edu

SAFE LIQUID SCINTILLATION & FLOW FLUIDS LIST

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

NOTE: Contact vendor or website for the fluid best suited for the laboratory's needs.

Rutgers Environmental Health and Safety (REHS)
74 Street 1603, Building 4116, Livingston Campus
Piscataway, NJ 08854
P: 848-445-2550 | F: 732-445-3109
Website: https://ipo.rutgers.edu/rehs

REHS does <u>not</u> approve of the list below that contains HAZARDOUS scintillation and flow fluids. Labs shall avoid using these fluids, and instead use a fluid from the "SAFE" list.

HAZARDOUS LIQUID SCINTILLATION & FLOW FLUIDS LIST

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

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EFFICIENCY / MDA CALCULATIONS

The University is required to determine the counting efficiency and minimum detectable activity (MDA) of liquid scintillation and gamma counters in order to properly evaluate wipe test results. Laboratory wipe tests must be recorded in units of disintegrations per minute (dpm) as per Nuclear Regulatory Commission (NRC) regulations.

Users of tritium (H-3), Fe-55, and Ni-63 are required to perform the following procedures on a quarterly basis for, at a minimum, the least efficient isotope that is used in the lab.

Users of gamma emitters and mid-high energy beta emitters are not required to perform quarterly wipe tests unless the Authoree/Principal Investigator requires them for their lab or there is a need to perform wipe tests.

A. Determination of Efficiency (E):

1. Use a standard of known activity. **NOTE**: 1 µCi = 2.2 x 10^6 dpm
2. Set the gain and discriminator levels ("windows") according to the manufacturer's recommendation for the isotope to be counted.
3. Count the blank (background) and standard for one (1) minute to obtain counts per minute (cpm) for both.
4. Determine the net cpm of the standard by subtracting the background cpm from the standard cpm.

   net standard cpm = standard cpm – background cpm
5. Calculate the efficiency:

   E = net standard (cpm) ÷ activity of standard (dpm)
6. Divide cpm of wipe samples by the efficiency to convert to dpm.

   dpm of wipe samples = cpm of wipe samples ÷ E

B. Determination of Minimum Detectable Activity (MDA):

1. Count the blank (background) for one (1) minute.
2. Calculate the MDA:

   $$\text{MDA (cpm)} = 4.65\sqrt{\text{background (cpm)}}$$
3. To obtain results in dpm, divide the MDA by the efficiency.

   MDA (dpm) = MDA (cpm) ÷ E (as decimal number)
4. Record all calculations and results in the lab's wipe test notebook. The MDA of the counting instrument should be less than 100 dpm. If the MDA is greater than 100 dpm, notify REHS.

RADIATION SURVEY METERS

Radiation meters are used to detect ionizing radiation. All laboratories working with radioactive materials must possess a survey meter with an appropriate detector. The following information is intended to help you make an appropriate purchase. Contact REHS with any questions about meters or detectors (radgroup@ipo.rutgers.edu).

SURVEY METER	DETECTORS/PROBES	
		
Ludlum Model 3 Survey Meter • Alpha, Beta, & Gamma surveying • 4-Range Analog Ratemeter • The most common meter • Very reliable instrument • Low price https://ludlums.com/products/all-products/product/model-3	**Geiger-Mueller (GM) – "Pancake"** (Example: Ludlum Model 44-9) • For detection of Beta Emitters • Cannot detect H-3 • Detects radiation via ionization of a gas contained inside the probe. The ejected electrons are then collected and counted. • The probe has a very thin membrane that is under pressure and easily punctured. **Commonly used to detect:** C-14, Ca-45, P-32, P-33, S-35	**Sodium Iodide (NaI)** (Example: Ludlum Model 44-3) • 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:** Cr-51, I-125, I-131

PURCHASING A METER

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

Ludlum Vendors
- Atlantic Nuclear (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 request them to perform an efficiency check and add the meter to the REHS database. If a lab needs a loaner meter or detector, contact REHS to see if they have loaner supplies.

CALIBRATIONS/REPAIR

On an annual basis, REHS checks the operational functioning and efficiency of the laboratory meters against a known P-32 and C-14 check source for G-M pancake probes and an I-129 source for NaI probes. If the meter fails the efficiency check, REHS tries to resolve the problem in-house; otherwise, REHS may need to send it to the appropriate vendor for repair. The lab is expected to cover the cost of any repairs to their survey meters & probes.

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Website: https://ipo.rutgers.edu/rehs
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POST-EXPERIMENT SURVEY FORM FOR RAM LAB

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

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RADIONUCLIDE INVENTORY LOG

PI Name	PI Number	Building	Room/Lab

Radionuclide	Activity Received (mCi)	Chemical Name	# of Vials/Articles

Date Received:		Ship Code:	

***NOTE*: in the table below, circle either 'mCi' or 'µCi' according to the unit of measure for that entire column.**

RAM USE			VIAL BALANCE
Date	Amount mCi | µCi		Amount mCi | µCi

WASTE DISPOSAL					WASTE TOTAL
Date	Solid mCi | µCi	Liquid mCi | µCi	LSV mCi | µCi	Bio mCi | µCi	Amount mCi | µCi

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POST-IODINATION SURVEY FORM

REHS policy requires that a contamination survey be conducted immediately after an iodination is performed.

SURVEY METHOD	AREAS TO SURVEY
Wipe tests	Bench tops, floors, instruments, and anything else that could have been contaminated during this procedure
Calibrated, low energy sodium iodide (NaI) probe in a ***low background area*** OR wipe tests	Personal surveys of lab coats, shoes, hands, face, etc.

WIPE TESTS

Results in disintegrations per minute (dpm)

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

PERSONAL SURVEY

Results in counts per minute (cpm)

Instrument Model #:		Serial #:	
Background (**cpm**):			
Labcoat (**cpm**):		Hands (**cpm**):	
Shoes (**cpm**):		Face (**cpm**):	

NOTE:

Any wipe test survey result above 100 dpm/100 cm² shall be decontaminated and re-surveyed.

Any personal contamination above background must be reported to REHS immediately (P: 848-445-2550).

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

Name (PRINTED) _____ Name (SIGNED) _____ Date _____

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TRANSFER OF RADIOACTIVE MATERIAL

FORM 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 for review (i.e., ensure the recipient PI and their permit is allowed to possess the RAM, etc.).
- Send this form (all fields filled in) to the REHS Radiation Safety Group via one of the options below, then await a response by REHS.
    - Email: radgroup@ipo.rutgers.edu
    - Fax: 732-445-3109

Contact REHS (848-445-2550 or radgroup@ipo.rutgers.edu) with questions or issues.

REQUESTED TRANSFER DATE: _____

RADIONUCLIDE INFORMATION

Isotope: _____

Activity (mCi): _____ mCi

Chemical Form: _____

TRANSFER INFORMATION

TRANSFER FROM:		**TRANSFER TO:**	
PI Name:		PI Name:	
PI # :		PI # :	
Building and Lab:		Building and Lab:	
Phone:		Phone:	
Email:		Email:	
Alternate Contact:		Alternate Contact:	

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REHS INSPECTION REPORT DETAILS (RAM)

REHS performs quarterly or semi-annual inspections of all radioactive material (RAM) locations. When the inspection is completed, REHS provides a copy of the inspection report (which explains the inspection checklist used by REHS and results) to the PI. Items marked with an X for "unsatisfactory" should be corrected immediately. PIs who receive a Notice of Violation (NOV) as a result of this inspection are required to respond, in writing, within 2 weeks of receiving the NOV.

IMPORTANT: The information provided here is a very brief description of each topic listed. For comprehensive, in-depth details, please refer to the Rutgers University ***Radiation Safety Guide***. Additionally, radiation safety information and forms are available on the REHS website here: https://ipo.rutgers.edu/rehs/labrad-radiation-1
Contact the REHS Radiation Safety Office with any questions: radgroup@ipo.rutgers.edu or 848-445-2550

LAB(S)
The labs listed under the PI's authorization that are approved for RAM work and subject to inspection.

SECURITY
Per Rutgers security policy, all RAM must be secured, and stock RAM must be locked when it is not in use or under direct surveillance. Lab staff should challenge any unfamiliar people who walk into the lab.

- If the lab has one entrance/exit, security can be accomplished by locking the door when no one is present.
- If the lab has more than one entrance/exit, security can be accomplished by locking the refrigerator, freezer, or other storage cabinet where RAM is stored or storing RAM in a lock box.

CAUTION SIGN
All entry doors into labs and other hazardous areas must be posted with caution/warning signage that lists all the hazards that the lab may possess as well as emergency contact information. All entry doors into RAM labs must be posted with a sign that has the radioactive warning trefoil symbol and the words "**CAUTION-RADIOACTIVE MATERIALS**."

2 REQUIRED POSTINGS
REHS will check each RAM lab for the presence of two (2) required postings and replace any that are missing, torn, or out of date:

1. NJDEP Notice to Employees
2. REHS Radioactive Material Laboratory Safety Rules (lists Rutgers' NJDEP RAM License numbers and applicable rules/regulations)

QUARTERLY WIPE TESTS/USE STATEMENTS
(Only for users of H-3, Fe-55, and Ni-63)
Labs that use H-3, Fe-55, and/or Ni-63 must perform wipe testing for contamination in any calendar quarter that those radioisotopes are used. All wipes must be expressed in units of dpm (not cpm). The liquid scintillation counter printout sheet (including the date) should be attached to the quarterly wipe test results 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 wipe test logbook. *NOTE: for a common/shared lab used between 2 or more PIs and their workers, the lab must be wipe tested by each RAM PI every quarter.*

MDA / EFFICIENCY

(Only for users of H-3, Fe-55, and Ni-63)

Calculations of minimum detectable activity (MDA) and efficiency must be performed and documented when H-3, Fe-55, and/or Ni-63 are used within a calendar quarter. MDA should be less than 100 dpm. REHS provides a downloadable Excel spreadsheet (titled ***Wipe Test Form (Excel)*** on the REHS website) that will auto-calculate these numbers for the researcher.

DAILY SURVEYS

After every use of RAM, surveys must be performed as follows:

- Personal survey (includes hands, clothing, shoes, etc.)
- Work area survey (include bench tops, floors, equipment used, fume hoods, regular trash container, etc.)

The method of survey equipment will depend on the radioisotope used:

- Survey meter: for gamma emitters and mid-high energy beta emitters
- Wipe tests: for low energy beta emitters

These surveys must be documented a minimum of once per day of RAM use on the ***Post-Experiment Survey Form*** (available on the REHS website).

SURVEY METERS

REHS evaluates each lab's survey meter(s) and detector probes (e.g., G-M "pancake-type" detector, NaI probe) to ensure the instrument is appropriate for the radioisotopes used. 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.

RAM WASTE LABELED

All radioactive waste containers must be labeled with a "**CAUTION-RADIOACTIVE MATERIALS**" sticker and must have a yellow waste card associated with them that indicates the isotope and approximate activity. A temporary waste container (i.e., small tabletop acrylic plexiglass box) must be labeled with a "**CAUTION-RADIOACTIVE MATERIALS**" sticker and either emptied into the primary radioactive waste container at the end of the day or have a yellow waste card associated with it. If the lab supplies their own containers, appropriate containers for the RAM must be utilized (see ***Radiation Safety Guide*** for more details).

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 WASTE SEGREGATION

Radioactive waste must be segregated according to the isotope's half-life (*see the REHS website or* ***Radiation Safety Guide*** *for segregation schemes*). **DRAIN DISPOSAL OF LIQUID RADIOACTIVE WASTE IS PROHIBITED.**

YELLOW WASTE CARD

A Radioactive Waste Disposal Form ("yellow waste card") must be displayed and associated with each radioactive waste container, with all sections completely documented.

- Section I lists the Authoree information such as PI name, 4-digit PI number, the building and room number where the RAM waste is located, etc.

- Section II lists radioisotope, chemical, and activity information. This section is documented each time RAM waste is placed into the container.
- Section III lists liquid RAM waste and RAM waste summary. 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 documented in this section.
- The card must be signed by an authorized radiation worker.

FOOD/DRINK/SMOKING/COSMETICS=ABSENT

Eating, drinking, smoking/vaping, and applying cosmetics are prohibited in all labs. Food and beverages shall not be stored in RAM labs. Evidence of prior food or drink consumption (i.e., food wrappers, coffee cups, water bottles, etc. in trash cans) will also 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-radiation workers by using general lab safety practices to avoid RAM contamination. Personal protective equipment (PPE), such as double gloves, buttoned lab coats, and safety glasses or goggles, must be worn when handling RAM. Shorts, skirts, and open-toed shoes do not provide adequate protection against RAM, chemicals, sharps, etc., and therefore, should not be worn when working in the lab or handling RAM.

Shielding shall be used if necessary for certain radioisotopes. Radiation dosimeters, if issued, must be properly worn when working with radioactive materials. Dosimeter badges/rings must not be lent to others or stored near sources of radiation. After RAM packages are delivered to the lab by REHS, the radiation worker must check the package interior and inner vial for contamination (see ***Radioactive Material Package Receipt SOP*** on the REHS website). Before packaging/boxes that are free of RAM contamination are placed into regular trash, all "radioactive" symbols and verbiage must be defaced. Lead must be wipe tested and meter-surveyed for RAM contamination (see ***Lead Disposal SOP*** on the REHS website for guidance).

RADIATION SAFETY TRAINING=UTD

All individuals who work with radioisotopes, including Authorees, must be up to date (UTD) on radiation safety training. All Authorees/radiation workers must first attend an initial radiation safety training class in-person PRIOR to working with RAM as well as complete online refresher radiation safety training annually thereafter. If an Authoree receives a NOV, then the Authoree and all radiation workers must attend in-person refresher training. Visit the REHS website to see the schedule for initial radiation safety training sessions as well as register for initial or online refresher radiation safety training classes.

INVENTORY

Each lab shall maintain a written inventory of radioisotopes received, used, and wasted/disposed. Inventory log sheets that are pre-printed with the PI and RAM vial information are provided by REHS with each RAM package delivered to the lab. A blank version of the radionuclide inventory log is available on the REHS website as ***RAM Inventory Log***. Additionally, Inventory Verification Reports (IVRs) are emailed to each Authoree every 6 months for confirmation that receipt and disposal amounts are correct and align between Authoree records and REHS records. 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 to detect any possible RAM contamination (only applies to RAM that is detectable by a survey meter). Lab personnel and/or the Authoree will be notified immediately if RAM contamination is found.

RAM LAB CLEARANCE CHECKLIST

Building:		**Lab:**	
PI Name:		**Alt. Contact Name:**	
PI Email:		**Alt. Contact Email:**	
PI Phone:		**Alt. Contact Phone:**	

DETAILS	DONE	N/A
NOTIFY REHS OF INTENDED CHANGE (check all that apply): ☐ Moving radioactive material (RAM) 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. Request a radioactive waste pickup via website (https://halflife.rutgers.edu/forms/radwaste.php) or phone (848-445-2550). Carefully review the inventory to ensure all waste is accounted for.	☐	☐
RADIOACTIVE MATERIALS – OPEN/UNSEALED SOURCES Stock RAM can be prepared and transported by REHS upon request. Lab staff are prohibited from transferring or transporting RAM without REHS approval.	☐	☐
RADIOACTIVE MATERIALS – SEALED SOURCES Federal (NRC, DOT) and State (NJDEP) regulations specifically require REHS to supervise the relocation or transfer of all radiation sources. Notify REHS in advance if equipment containing a sealed source (e.g., liquid scintillation counter, gas chromatograph with an electron capture detector, etc.) needs to be moved, transferred, or disposed of.	☐	☐
LABELED EQUIPMENT All equipment labeled "radioactive" must be surveyed. • Wipe test results: less than 100 dpm/100 cm^2 • Meter survey results < or = background measurement (excludes H-3, Fe-55, Ni-63) If survey results align with criteria above, then remove or deface "radioactive" labels. If the wipe test **OR** meter survey results exceed the criteria, then decontaminate and re-survey the area. Contact REHS if the area cannot be decontaminated sufficiently.	☐	☐
FREEZERS Accumulated ice in freezers that were used to store H-3 or C-14 should be sampled and analyzed for contamination. Contact REHS for guidance.	☐	☐
WIPE TEST SURVEY OF LAB Perform a wipe test of the laboratory. Decontaminate and re-survey any area that exceeds 100 dpm/100 cm^2. Email wipe test results to: radgroup@ipo.rutgers.edu	☐	☐

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DOSIMETRY – REGULATIONS, RULES & LIMITATIONS

Rutgers Environmental Health & Safety (REHS) provides dosimetry to employees who work with radiation sources that emit a certain level of ionizing radiation. According to the regulations outlined by the New Jersey Department of Environmental Protection (NJDEP), Rutgers University is not required to provide dosimetry (radiation monitoring badges) to a majority of researchers working with radioactive materials (RAM). However, Rutgers does provide dosimetry to a select worker population on campus who work with high−energy beta emitters, select gamma emitters, and some radiation producing machine sources.

You have met our internal criteria for dosimetry. Enclosed, you will find your assigned radiation dosimeter(s), which are designed to monitor your occupational radiation exposure. REHS will monitor your radiation dose for each wear period to ensure exposure levels do not exceed NJDEP's occupational limits. Ensure that you understand the rules and limitations of your dosimeter(s) (outlined below). **Additional important information to read pertaining to dosimeters is available on the REHS website here**: https://ipo.rutgers.edu/rehs/labrad-dosimeter-rules

For any questions/concerns, contact the REHS Radiation Safety office: radgroup@ipo.rutgers.edu or 848-445-2550

RADIATION DOSIMETER RULES

- **Wear dosimeters properly**. All dosimeters must be worn at all times while in the controlled radiation area.
  - **Whole body badges** measure deep and shallow doses. Wear these badges under your lab coat on the torso between the neck and pelvic area with the badge label facing the radiation source. If wearing lead/lead-equivalent personal protective equipment (PPE), such as a lead apron & thyroid shield, the badge must be worn on the outside of the lead/lead-equivalent PPE.
  - **Ring badges** measure extremity doses. Wear these rings under your gloves on the finger of the hand that you use to do most of your radiation work or is nearest to the radiation source.
- **Do not share your dosimeter with another person**. Your dosimeter is assigned to you. Any dose received by the dosimeter will be recorded under your name and kept as a permanent record.
- **Return dosimeters on time**. In order to process used dosimeters, REHS will exchange dosimeters from the previous wear period with a new batch for the next wear period. Most dosimeters are exchanged every three (3) months in the beginning of January, April, July, and October. Fetal dosimeters are exchanged in the first week of every month. Ensure your dosimeter is available for exchange during REHS' designated exchange periods. **Your dosimeter(s) cannot be submitted for timely processing if they are not exchanged on time**. A non-returned/late fee may be issued for dosimeters that are not returned to REHS within 90 days after the end of the wear period.
- **Do not deliberately expose dosimeters to radiation and/or heat**. Unintended radiation or heat can yield inaccurately elevated radiation doses that are not reflective of your occupational exposure. Unintended heat also has the potential to erase any recorded exposures. Do not leave your dosimeter in or next to any radiation sources, on a window sill, near a space heater or heating vent, inside a hot car, or at other places that are hot or exposed to the sun.

  If you think your dosimeter was accidentally exposed to radiation/heat, contact REHS for guidance.
- **Store your dosimeter at a safe distance from a radiation source** where radiation levels are below background, and either in the lab or a designated area when not in use.

- **Do not take your dosimeter home or off campus premises**. If a dosimeter is brought home or off-premises, it could be exposed to further radiation and/or heat. The person may also forget to bring it back to the lab.
- **Do not wear your dosimeter during personal medical tests** (e.g., medical x-rays, dentistry appointments, nuclear medicine procedures, etc.), as these are not occupational radiation doses.
- **Notify REHS if your dosimeter is lost or damaged**. REHS can quickly issue a replacement dosimeter.
- **Notify REHS when your work with radiation sources has changed, you no longer require a dosimeter, or you depart the university**.

RADIATION DOSIMETER LIMITATIONS

- **Dosimeters are passive devices that record the amount of external radiation that you are exposed to**. At certain intervals, the used dosimeters are mailed to the dosimetry vendor for processing. Several weeks later, the results of your dosimeter exposures are then reported to REHS. Dosimeters do not provide any active protection against radiation in real time, and they do not absorb radiation. Your radiation dosimeter is purely for the purpose of monitoring the amount of radiation you may have been exposed to during your occupational work so that you do not exceed the regulatory limits set forth by the NJDEP.
- **Dosimeters have a minimum detectable level for radiation**; therefore, a dose less than these levels will not be recorded or reported.
    - Minimum detectable level for a whole body badge = 10 mrem
    - Minimum detectable level for a ring dosimeter = 20 mrem

  If "**ND**" is listed on your radiation exposure report, then the reportable dose was **non-detectable** (less than the minimum detectable level of the dosimeter).

  Your dosimeter will not record doses from certain radioisotopes that have lower beta energies (e.g., H-3, C-14, S-35, etc.) which emit radiation that is too low for the dosimeter to record. The dosimeters used at the university work best with higher energy beta emitters (e.g., P-32, etc.), gamma emitters (e.g., Cr-51, I-125, etc.), and x-rays.
- **Dosimeters will record any external radiation exposure above their minimum detectable level**. Radiation sources that a dosimeter can detect above its minimum detectable level within a certain unshielded distance are:
    - Radiation producing machines that emit ionizing radiation beyond the unit itself (typically, those used for medical use)
    - Certain radioactive materials (excluding certain radioisotopes that have lower beta energies)
    - NOTE: if your dosimeter(s) is **stored** near any radiation emitting source, it will record a dose that is not reflective of your occupational exposure.

  NOTEWORTHY INFORMATION:
    - When the ALARA principles are followed, the radiation dose recorded by the dosimeter is usually low or below the minimum detectable limit.
    - Most analytical radiation producing machines (e.g., electron microscopes, etc.) used at Rutgers have built-in shielding that contains the radiation within the unit itself, thus eliminating radiation emission to bystanders when the machine is used as intended.
    - Radioactive materials that are used in a university setting, such as Rutgers, are usually in small quantities/activities. Therefore, the radiation dose recorded by the dosimeter is usually low or below the minimum detectable limit.

- **Dosimeters used at Rutgers will not record radioactive material taken into the body**. If a small quantity/activity of radioactive material accidentally enters into the body (i.e., by inhalation, ingestion, injection, skin absorption), these internal doses will not be recorded by the dosimeter.

  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 as well as the use of proper personal protective equipment (e.g., lab coat, gloves, safety glasses/goggles, etc.).

  To identify potential areas of radioactive contamination which, therefore, helps you avoid potential internal exposure, surveys that are appropriate for the type/energy of the radioisotope can be performed (i.e., using a hand-held survey meter and/or conducting wipe testing).

- **If you have had a medical test that involved the use of a radionuclide (e.g., nuclear medicine scan, stress test, etc.), you should not wear your dosimeter(s) at work during the radionuclide decay timeframe**. The radioactive material used for these medical procedures/tests usually involves gamma-emitting radionuclides, which would cause your dosimeter(s) to record a falsely elevated dose. These personal medical procedures/tests are not occupational exposures to radiation.

  Contact REHS if you are planning to have or have recently had a medical test or procedure involving radionuclides to discuss the situation/plan.

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.

REHS will send your radiation exposure report for the previous year ("Form 5") to you in April of the following year. If you do not receive a "Form 5," then your doses were "ND" (non-detectable). You may request a copy of your radiation exposure report for any timeframe by contacting REHS-Radiation Safety.

REMINDER: Please notify REHS-Radiation Safety when your work with radiation sources has changed, you no longer require a dosimeter, or you depart the university. If you will no longer require a dosimeter or depart the university, please leave your dosimeter(s) in a location where REHS can retrieve them.

CONTACT INFO FOR REHS-RADIATION SAFETY

EMAIL: radgroup@ipo.rutgers.edu

PHONE: 848-445-2550

FAX: 732-445-3109

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FETAL DOSIMETRY – REGULATIONS, RULES & LIMITATIONS

You are receiving a fetal dosimeter ("fetal badge") because you have declared your pregnancy in writing to Rutgers Environmental Health & Safety (REHS). Ensure that you understand the rules and limitations of your dosimeter (outlined below) as well as the regulations set forth by the NJ Department of Environmental Protection (NJDEP). **Additional important information to read pertaining to dosimeters is available on the REHS website here**: https://ipo.rutgers.edu/rehs/labrad-dosimeter-rules

- Fetal badges record and measure deep doses of external radiation that would potentially expose the embryo/fetus.
- The radiation dose to the developing embryo/fetus shall not exceed the NJDEP occupational radiation exposure limit of 500 millirem (mrem) for the duration of the gestation/pregnancy period (10 months), and the monthly exposure should be limited to 50 mrem. Meeting this limit may require a change in work duties during your pregnancy. REHS will monitor the fetal dose on a monthly basis to ensure exposure levels do not exceed NJDEP's occupational limits.
- The fetal badge will be automatically cancelled at the end of one (1) year from the estimated date of conception unless you cancel the badge sooner, you withdraw your declaration of pregnancy, or your employment is discontinued.

For any questions/concerns, contact the REHS Radiation Safety office: radgroup@ipo.rutgers.edu or 848-445-2550

RADIATION DOSIMETER RULES

- **Wear dosimeters properly**. All dosimeters must be worn at all times while in the controlled radiation area.
  - The fetal badge is worn at the front of the person's waist, as close to the embryo/fetus as possible, with the badge label facing outwards towards the radiation source.
  - The fetal badge should be worn underneath a lab coat or shirt. If a lead/lead-equivalent apron is required for the task, the fetal badge must be worn underneath the lead/lead-equivalent apron.
  - The worker's personal radiation dosimeter(s) must also be worn (badge and/or ring) as usual.
- **Do not share your dosimeter with another person**. Your fetal badge is assigned to you for the duration of your pregnancy. Any dose received by the dosimeter will be recorded under your name and kept as a permanent record.
- **Return dosimeters on time**. In order to process used dosimeters, REHS will exchange your fetal badge from the previous month's wear period with a new fetal badge for the next month's wear period. Fetal badges are exchanged in the first week of every month. Ensure your dosimeter is available for exchange during REHS' designated exchange periods. **Your fetal badge cannot be submitted for timely processing if it is not exchanged on time**. A non–returned/late fee may be issued for dosimeters that are not returned to REHS within 90 days after the end of the wear period.
- **Do not deliberately expose dosimeters to radiation and/or heat**. Unintended radiation or heat can yield inaccurately elevated radiation doses that are not reflective of your occupational exposure. Unintended heat also has the potential to erase any recorded exposures. Do not leave your dosimeter in or next to any radiation sources, on a window sill, near a space heater or heating vent, inside a hot car, or at other places that are hot or exposed to the sun.

If you think your dosimeter was accidentally exposed to radiation/heat, contact REHS for guidance.

- **Store your dosimeter at a safe distance from a radiation source** where radiation levels are consistent with background, and either in the lab or a designated area when not in use.
- **Do not take your dosimeter home or off campus premises**. If a dosimeter is brought home or off–premises, it could be exposed to further radiation and/or heat. The person may also forget to bring it back to the lab.
- **Do not wear your dosimeter during personal medical tests** (e.g., medical x–rays, dentistry appointments, nuclear medicine procedures, etc.), as these are not occupational radiation doses.
- **Notify REHS if your dosimeter is lost or damaged**. REHS can quickly issue a replacement dosimeter.
- **Notify REHS when your work with radiation sources has changed, you no longer require a dosimeter, or you depart the university**.

RADIATION DOSIMETER LIMITATIONS

- **Dosimeters are passive devices that record the amount of external radiation that you or your embryo/fetus are exposed to**. At certain intervals (monthly for fetal badges), the used dosimeters are mailed to the dosimetry vendor for processing. Several weeks later, the results of your dosimeter exposures are then reported to REHS. Dosimeters do not provide any active protection against radiation in real time, and they do not absorb radiation. Your fetal badge is purely for the purpose of monitoring the amount of radiation that your embryo/fetus may have been exposed to during your occupational work so that you do not exceed the regulatory limits set forth by the NJDEP.
- **Dosimeters have a minimum detectable level for radiation**; therefore, a dose less than these levels will not be recorded or reported.
    - Minimum detectable level for a whole body badge = 10 mrem
    - Minimum detectable level for a ring dosimeter = 20 mrem

  If "**ND**" is listed on your radiation exposure report, then the reportable dose was **non–detectable** (less than the minimum detectable level of the dosimeter).

  Your dosimeter will not record doses from certain radioisotopes that have lower beta energies (e.g., H–3, C–14, S–35, etc.) which emit radiation that is too low for the dosimeter to record. The dosimeters used at the university work best with higher energy beta emitters (e.g., P–32, etc.), gamma emitters (e.g., Cr–51, I–125, etc.), and x–rays.
- **Dosimeters will record any external radiation exposure above their minimum detectable level**. Radiation sources that a dosimeter can detect above its minimum detectable level within a certain unshielded distance are:
    - Radiation producing machines that emit ionizing radiation beyond the unit itself (typically, those used for medical use)
    - Certain radioactive materials (RAM) (excluding certain radioisotopes that have lower beta energies)
    - NOTE: if your dosimeter(s) is **stored** near any radiation–emitting source, it will record a dose that is not reflective of your occupational exposure.

  NOTEWORTHY INFORMATION:
    - When the ALARA principles are followed, the radiation dose recorded by the dosimeter is usually low or below the minimum detectable limit.
    - Most analytical radiation producing machines (e.g., electron microscopes, etc.) used at Rutgers have built–in shielding that contains the radiation within the unit itself, thus eliminating radiation emission to bystanders when the machine is used as intended.
    - Radioactive materials that are used in a university setting, such as Rutgers, are usually in small quantities/activities. Therefore, the radiation dose recorded by the dosimeter is usually low or below the minimum detectable limit.

- **Dosimeters used at Rutgers will not record RAM taken into the body**. If a small quantity/activity of RAM accidentally enters into the body (i.e., by inhalation, ingestion, injection, skin absorption), these internal doses will not be recorded by the dosimeter.

  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 as well as the use of proper personal protective equipment (e.g., lab coat, gloves, safety glasses/goggles, etc.).

  To identify potential areas of radioactive contamination, which, therefore, helps you avoid potential internal exposure, surveys that are appropriate for the type/energy of the radioisotope can be performed (i.e., using a hand-held survey meter and/or conducting wipe testing).

- **If you have had a medical test that involved the use of a radionuclide (e.g., nuclear medicine scan, stress test, etc.), you should not wear your dosimeter(s) at work during the radionuclide decay timeframe**. The radioactive material used for these medical procedures/tests usually involves gamma–emitting radionuclides, which would cause your dosimeter(s) to record a falsely elevated dose. These medical procedures/tests are extremely rare for a pregnant person and not occupational exposures to radiation.

  Contact REHS if you are planning to have or have recently had a medical test or procedure involving radionuclides to discuss the situation/plan.

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.

REHS will send your radiation exposure report for the previous year ("Form 5") to you in April of the following year. If you do not receive a "Form 5," then your doses were "ND" (non–detectable). You may request a copy of your radiation exposure report for any timeframe by contacting REHS-Radiation Safety.

REMINDER: When you depart the university on maternity leave, please notify REHS-Radiation Safety and leave your last month's fetal dosimeter in a location where REHS can retrieve it.

CONTACT INFO FOR REHS-RADIATION SAFETY

All information concerning your pregnancy will be kept confidential.

EMAIL: radgroup@ipo.rutgers.edu

PHONE: 848-445-2550

FAX: 732-445-3109

Rutgers Environmental Health and Safety (REHS)
74 Street 1603, Building 4116, Livingston Campus
Piscataway, NJ 08854
P: 848-445-2550 | F: 732-445-3109
Website: https://ipo.rutgers.edu/rehs

DECLARATION OF PREGNANCY FORM

Workers who voluntarily declare their pregnancy to their employer will be entered into Rutgers University's fetal dosimetry program. Rutgers Environmental Health & Safety (REHS) will issue a fetal radiation dosimetry badge to all pregnant workers who either:

1) work directly with radioactive materials and/or radiation producing machines or
2) are concerned because they work in a radioactive materials lab.

REHS will monitor the fetal dose on a **MONTHLY** basis to ensure exposure levels do not exceed occupational limits set by the NJ Department of Environmental Protection (NJDEP) of 500 millirem (mrem) over 10 months.

BADGE INFO

Fetal badges record external radiation dose to the fetus and should be worn at the front of the person's waist (underneath lead/lead-equivalent apron if the apron is required for the task) at all times while in the controlled radiation area. The worker's personal radiation dosimeter(s) must also be worn (badge and/or ring).
Fetal badges will be exchanged **MONTHLY** on/about the first business day of every month.

QUESTIONS?

Contact REHS-Radiation Safety to schedule a consultation or discuss any questions (see next page). All details concerning your pregnancy will be kept confidential. Visit the REHS website for more information: https://ipo.rutgers.edu/rehs/labrad-radiation-1 , https://ipo.rutgers.edu/rehs/labrad-dosimeter-rules

FETAL DOSIMETRY PROGRAM

This is a 2-page document. Fill out all of the information below, read all of the information contained within this document, sign/date the form on the next page, and send the completed form to REHS-Radiation Safety.

NAME: _____ (Last) _____ (First) _____ (Middle)

SOCIAL SECURITY NUMBER: _____ DATE OF BIRTH: _____

EMAIL ADDRESS: _____

ESTIMATED CONCEPTION DATE: _____ ESTIMATED DUE DATE: _____

HOME or CAMPUS ADDRESS: _____

HOME PHONE: _____ CELL PHONE: _____

OFFICE ADDRESS: _____

LAB LOCATION: _____ OFFICE PHONE: _____

PRINCIPAL INVESTIGATOR'S NAME: _____

By submitting this form, I am declaring my pregnancy to inform Rutgers Environmental Health and Safety (REHS) and/or my principal investigator. I understand the following:

- The declaration remains in effect until the declared pregnant worker withdraws the declaration in writing or is no longer pregnant. This declaration will remain valid for one (1) year from the signature date unless withdrawn sooner.
- I was provided with the US Nuclear Regulatory Commission (NRC) Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure," and I understand the risks of radiation exposure while pregnant.
- I may ask my employer (e.g., Radiation Safety Officer, REHS, PI/Manager/Supervisor, etc.) any questions about radiation exposure, regulatory guides, and declared pregnant worker policies at Rutgers University.
- The radiation dose to the developing embryo/fetus shall not exceed the NJDEP occupational radiation exposure limit of 500 millirem (mrem) for the duration of the gestation/pregnancy period (10 months), and the monthly exposure should be limited to 50 mrem. Meeting this limit may require a change in work duties during my pregnancy.
- I will continue to minimize my exposure by following ALARA (As Low As Reasonably Achievable) principles and participate in a monitoring program for pregnant workers.
- I can request a copy of my radiation exposure history at any time by contacting REHS-Radiation Safety. Email: ***radgroup@ipo.rutgers.edu*** Phone: 848-445-2550

I am requesting to be entered into Rutgers' fetal dosimetry program and for a fetal badge to be issued to me. I understand that the fetal badge will be automatically cancelled at the end of one (1) year from the estimated date of conception unless I cancel the badge sooner, I withdraw my declaration, or my employment is discontinued.

SIGNATURE: _____ DATE: _____

FOR SUBMISSION OF THIS FORM OR QUESTIONS TO *REHS – RADIATION SAFETY*: (Email or fax preferred for secure submission)		
EMAIL:	radgroup@ipo.rutgers.edu	
FAX:	732-445-3109	
CAMPUS MAIL:	REHS – Radiation Safety 74 Street 1603, Building 4116, Livingston Campus	
FOR CONFIDENTIAL DISCUSSIONS: (Contact anyone listed below in REHS-Radiation Safety)		
Patrick McDermott	patrick.mcdermott@rutgers.edu	848-445-2550
Diana Smith	diana.smith@rutgers.edu	848-445-2550

Revision 3
JUNE 1999

U.S. Nuclear Regulatory Commission

REGULATORY GUIDE

Office of Nuclear Regulatory Research

REGULATORY GUIDE 8.13
(Draft was issued as DG-8014)

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

The Code of Federal Regulations in 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations," in Section 19.12, "Instructions to Workers," requires instruction in "the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed." The instructions must be "commensurate with potential radiological health protection problems present in the work place."

The Nuclear Regulatory Commission's (NRC's) regulations on radiation protection are specified in 10 CFR Part 20, "Standards for Protection Against Radiation"; and 10 CFR 20.1208, "Dose to an Embryo/Fetus," requires licensees to "ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv)." Section 20.1208 also requires licensees to "make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman." A declared pregnant woman is defined in 10 CFR 20.1003 as a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

This regulatory guide is intended to provide information to pregnant women, and other personnel, to help them make decisions regarding radiation exposure during pregnancy. This Regulatory Guide 8.13 supplements Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure" (Ref. 1), which contains a broad discussion of the risks from exposure to ionizing radiation.

Other sections of the NRC's regulations also specify requirements for monitoring external and internal occupational dose to a declared pregnant woman. In 10 CFR 20.1502, "Conditions Requiring Individual Monitoring of External and Internal Occupational Dose," licensees are required to monitor the occupational dose to a declared pregnant woman, using an individual monitoring device, if it is likely that the declared pregnant woman will receive, from external sources, a deep dose equivalent in excess of 0.1 rem (1 mSv). According to Paragraph (e) of 10 CFR 20.2106, "Records of Individual Monitoring Results," the licensee must maintain

records of dose to an embryo/fetus if monitoring was required, and the records of dose to the embryo/fetus must be kept with the records of dose to the declared pregnant woman. The declaration of pregnancy must be kept on file, but may be maintained separately from the dose records. The licensee must retain the required form or record until the Commission terminates each pertinent license requiring the record.

The information collections in this regulatory guide are covered by the requirements of 10 CFR Parts 19 or 20, which were approved by the Office of Management and Budget, approval numbers 3150-0044 and 3150-0014, respectively. The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

B. DISCUSSION

As discussed in Regulatory Guide 8.29 (Ref. 1), exposure to any level of radiation is assumed to carry with it a certain amount of risk. In the absence of scientific certainty regarding the relationship between low dose exposure and health effects, and as a conservative assumption for radiation protection purposes, the scientific community generally assumes that any exposure to ionizing radiation may cause undesirable biological effects and that the likelihood of these effects increases as the dose increases. At the occupational dose limit for the whole body of 5 rem (50 mSv) per year, the risk is believed to be very low.

The magnitude of risk of childhood cancer following in utero exposure is uncertain in that both negative and positive studies have been reported. The data from these studies "are consistent with a lifetime cancer risk resulting from exposure during gestation which is two to three times that for the adult" (NCRP Report No. 116, Ref. 2). The NRC has reviewed the available scientific literature and has concluded that the 0.5 rem (5 mSv) limit specified in 10 CFR 20.1208 provides an adequate margin of protection for the embryo/fetus. This dose limit reflects the desire to limit the total lifetime risk of leukemia and other cancers associated with radiation exposure during pregnancy.

In order for a pregnant worker to take advantage of the lower exposure limit and dose monitoring provisions specified in 10 CFR Part 20, the woman must declare her pregnancy in writing to the licensee. A form letter for declaring pregnancy is provided in this guide or the licensee may use its own form letter for declaring pregnancy. A separate written declaration should be submitted for each pregnancy.

C. REGULATORY POSITION

1. Who Should Receive Instruction

Female workers who require training under 10 CFR 19.12 should be provided with the information contained in this guide. In addition to the information contained in Regulatory Guide 8.29 (Ref. 1), this information may be included as part of the training required under 10 CFR 19.12.

2. Providing Instruction

The occupational worker may be given a copy of this guide with its Appendix, an explanation of the

contents of the guide, and an opportunity to ask questions and request additional information. The information in this guide and Appendix should also be provided to any worker or supervisor who may be affected by a declaration of pregnancy or who may have to take some action in response to such a declaration.

Classroom instruction may supplement the written information. If the licensee provides classroom instruction, the instructor should have some knowledge of the biological effects of radiation to be able to answer questions that may go beyond the information provided in this guide. Videotaped presentations may be used for classroom instruction. Regardless of whether the licensee provides classroom training, the licensee should give workers the opportunity to ask questions about information contained in this Regulatory Guide 8.13. The licensee may take credit for instruction that the worker has received within the past year at other licensed facilities or in other courses or training.

3. Licensee's Policy on Declared Pregnant Women

The instruction provided should describe the licensee's specific policy on declared pregnant women, including how those policies may affect a woman's work situation. In particular, the instruction should include a description of the licensee's policies, if any, that may affect the declared pregnant woman's work situation after she has filed a written declaration of pregnancy consistent with 10 CFR 20.1208.

The instruction should also identify who to contact for additional information as well as identify who should receive the written declaration of pregnancy. The recipient of the woman's declaration may be identified by name (e.g., John Smith), position (e.g., immediate supervisor, the radiation safety officer), or department (e.g., the personnel department).

4. Duration of Lower Dose Limits for the Embryo/Fetus

The lower dose limit for the embryo/fetus should remain in effect until the woman withdraws the declaration in writing or the woman is no longer pregnant. If a declaration of pregnancy is withdrawn, the dose limit for the embryo/fetus would apply only to the time from the estimated date of conception until the time the declaration is withdrawn. If the declaration is not withdrawn, the written declaration may be considered expired one year after submission.

5. Substantial Variations Above a Uniform Monthly Dose Rate

According to 10 CFR 20.1208(b), "The licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of this section," that is, 0.5 rem (5 mSv) to the embryo/fetus. The National Council on Radiation Protection and Measurements (NCRP) recommends a monthly equivalent dose limit of 0.05 rem (0.5 mSv) to the embryo/fetus once the pregnancy is known (Ref. 2). In view of the NCRP recommendation, any monthly dose of less than 0.1 rem (1 mSv) may be considered as not a substantial variation above a uniform monthly dose rate and as such will not require licensee justification. However, a monthly dose greater than 0.1 rem (1 mSv) should be justified by the licensee.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees and applicants regarding the NRC staff's plans for using this regulatory guide.

Unless a licensee or an applicant proposes an acceptable alternative method for complying with the specified portions of the NRC's regulations, the methods described in this guide will be used by the NRC staff in the evaluation of instructions to workers on the radiation exposure of pregnant women.

REFERENCES

1. USNRC, "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.

2. National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, Bethesda, MD, 1993.

APPENDIX

QUESTIONS AND ANSWERS CONCERNING PRENATAL RADIATION EXPOSURE

1. Why am I receiving this information?

The NRC's regulations (in 10 CFR 19.12, "Instructions to Workers") require that licensees instruct individuals working with licensed radioactive materials in radiation protection as appropriate for the situation. The instruction below describes information that occupational workers and their supervisors should know about the radiation exposure of the embryo/fetus of pregnant women.

The regulations allow a pregnant woman to decide whether she wants to formally declare her pregnancy to take advantage of lower dose limits for the embryo/fetus. This instruction provides information to help women make an informed decision whether to declare a pregnancy.

2. If I become pregnant, am I required to declare my pregnancy?

No. The choice whether to declare your pregnancy is completely voluntary. If you choose to declare your pregnancy, you must do so in writing and a lower radiation dose limit will apply to your embryo/fetus. If you choose not to declare your pregnancy, you and your embryo/fetus will continue to be subject to the same radiation dose limits that apply to other occupational workers.

3. If I declare my pregnancy in writing, what happens?

If you choose to declare your pregnancy in writing, the licensee must take measures to limit the dose to your embryo/fetus to 0.5 rem (5 millisievert) during the entire pregnancy. This is one-tenth of the dose that an occupational worker may receive in a year. If you have already received a dose exceeding 0.5 rem (5 mSv) in the period between conception and the declaration of your pregnancy, an additional dose of 0.05 rem (0.5 mSv) is allowed during the remainder of the pregnancy. In addition, 10 CFR 20.1208, "Dose to an Embryo/Fetus," requires licensees to make efforts to avoid substantial variation above a uniform monthly dose rate so that all the 0.5 rem (5 mSv) allowed dose does not occur in a short period during the pregnancy.

This may mean that, if you declare your pregnancy, the licensee may not permit you to do some of your normal job functions if those functions would have allowed you to receive more than 0.5 rem, and you may not be able to have some emergency response responsibilities.

4. Why do the regulations have a lower dose limit for the embryo/fetus of a declared pregnant woman than for a pregnant worker who has not declared?

A lower dose limit for the embryo/fetus of a declared pregnant woman is based on a consideration of greater sensitivity to radiation of the embryo/fetus and the involuntary nature of the exposure. Several scientific advisory groups have recommended (References 1 and 2) that the dose to the embryo/fetus be limited to a fraction of the occupational dose limit.

5. What are the potentially harmful effects of radiation exposure to my embryo/fetus?

The occurrence and severity of health effects caused by ionizing radiation are dependent upon the type and total dose of radiation received, as well as the time period over which the exposure was received. See Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Exposure" (Ref. 3), for more information. The main concern is embryo/fetal susceptibility to the harmful effects of radiation such as cancer.

6. Are there any risks of genetic defects?

Although radiation injury has been induced experimentally in rodents and insects, and in the experiments was transmitted and became manifest as hereditary disorders in their offspring, radiation has not been identified as a cause of such effect in humans. Therefore, the risk of genetic effects attributable to radiation exposure is speculative. For example, no genetic effects have been documented in any of the Japanese atomic bomb survivors, their children, or their grandchildren.

7. What if I decide that I do not want any radiation exposure at all during my pregnancy?

You may ask your employer for a job that does not involve any exposure at all to occupational radiation dose, but your employer is not obligated to provide you with a job involving no radiation exposure. Even if you receive no occupational exposure at all, your embryo/fetus will receive some radiation dose (on average 75 mrem (0.75 mSv)) during your pregnancy from natural background radiation.

The NRC has reviewed the available scientific literature and concluded that the 0.5 rem (5 mSv) limit provides an adequate margin of protection for the embryo/fetus. This dose limit reflects the desire to limit the total lifetime risk of leukemia and other cancers. If this dose limit is exceeded, the total lifetime risk of cancer to the embryo/fetus may increase incrementally. However, the decision on what level of risk to accept is yours. More detailed information on potential risk to the embryo/fetus from radiation exposure can be found in References 2-10.

8. What effect will formally declaring my pregnancy have on my job status?

Only the licensee can tell you what effect a written declaration of pregnancy will have on your job status. As part of your radiation safety training, the licensee should tell you the company's policies with respect to the job status of declared pregnant women. In addition, before you declare your pregnancy, you may want to talk to your supervisor or your radiation safety officer and ask what a declaration of pregnancy would mean specifically for you and your job status.

In many cases you can continue in your present job with no change and still meet the dose limit for the embryo/fetus. For example, most commercial power reactor workers (approximately 93%) receive, in 12 months, occupational radiation doses that are less than 0.5 rem (5 mSv) (Ref. 11). The licensee may also consider the likelihood of increased radiation exposures from accidents and abnormal events before making a decision to allow you to continue in your present job.

If your current work might cause the dose to your embryo/fetus to exceed 0.5 rem (5 mSv), the licensee has various options. It is possible that the licensee can and will make a reasonable accommodation that will allow you to continue performing your current job, for example, by having another qualified employee do a small part of the job that accounts for some of your radiation exposure.

9. What information must I provide in my written declaration of pregnancy?

You should provide, in writing, your name, a declaration that you are pregnant, the estimated date of conception (only the month and year need be given), and the date that you give the letter to the licensee. A form letter that you can use is included at the end of these questions and answers. You may use that letter, use a form letter the licensee has provided to you, or write your own letter.

10. To declare my pregnancy, do I have to have documented medical proof that I am pregnant?

NRC regulations do not require that you provide medical proof of your pregnancy. However, NRC regulations do not preclude the licensee from requesting medical documentation of your pregnancy, especially if a change in your duties is necessary in order to comply with the 0.5 rem (5 mSv) dose limit.

11. Can I tell the licensee orally rather than in writing that I am pregnant?

No. The regulations require that the declaration must be in writing.

12. If I have not declared my pregnancy in writing, but the licensee suspects that I am pregnant, do the lower dose limits apply?

No. The lower dose limits for pregnant women apply only if you have declared your pregnancy in writing. The United States Supreme Court has ruled (in *United Automobile Workers International Union v. Johnson Controls, Inc*., 1991) that "Decisions about the welfare of future children must be left to the parents who conceive, bear, support, and raise them rather than to the employers who hire those parents" (Reference 7). The Supreme Court also ruled that your employer may not restrict you from a specific job "because of concerns about the next generation." Thus, the lower limits apply only if you choose to declare your pregnancy in writing.

13. If I am planning to become pregnant but am not yet pregnant and I inform the licensee of that in writing, do the lower dose limits apply?

No. The requirement for lower limits applies only if you declare in writing that you are already pregnant.

14. What if I have a miscarriage or find out that I am not pregnant?

If you have declared your pregnancy in writing, you should promptly inform the licensee in writing that you are no longer pregnant. However, if you have not formally declared your pregnancy in writing, you need not inform the licensee of your nonpregnant status.

15. How long is the lower dose limit in effect?

The dose to the embryo/fetus must be limited until you withdraw your declaration in writing or you

inform the licensee in writing that you are no longer pregnant. If the declaration is not withdrawn, the written declaration may be considered expired one year after submission.

16. If I have declared my pregnancy in writing, can I revoke my declaration of pregnancy even if I am still pregnant?

Yes, you may. The choice is entirely yours. If you revoke your declaration of pregnancy, the lower dose limit for the embryo/fetus no longer applies.

17. What if I work under contract at a licensed facility?

The regulations state that you should formally declare your pregnancy to the licensee in writing. The licensee has the responsibility to limit the dose to the embryo/fetus.

18. Where can I get additional information?

The references to this Appendix contain helpful information, especially Reference 3, NRC's Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure," for general information on radiation risks. The licensee should be able to give this document to you.

For information on legal aspects, see Reference 7, "The Rock and the Hard Place: Employer Liability to Fertile or Pregnant Employees and Their Unborn Children—What Can the Employer Do?" which is an article in the journal *Radiation Protection Management*.

You may telephone the NRC Headquarters at (301) 415-7000. Legal questions should be directed to the Office of the General Counsel, and technical questions should be directed to the Division of Industrial and Medical Nuclear Safety.

You may also telephone the NRC Regional Offices at the following numbers: Region I, (610) 337-5000; Region II, (404) 562-4400; Region III, (630) 829-9500; and Region IV, (817) 860-8100. Legal questions should be directed to the Regional Counsel, and technical questions should be directed to the Division of Nuclear Materials Safety.

REFERENCES FOR APPENDIX

1. National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, Bethesda, MD, 1993.

2. International Commission on Radiological Protection, *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Ann. ICRP 21: No. 1-3, Pergamon Press, Oxford, UK, 1991.

3. USNRC, "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.[11] (Electronically available at www.nrc.gov/NRC/RG/index.html)

4. Committee on the Biological Effects of Ionizing Radiations, National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiation* (BEIR V), National Academy Press, Washington, DC, 1990.

5. United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation*, United Nations, New York, 1993.

6. R. Doll and R. Wakeford, "Risk of Childhood Cancer from Fetal Irradiation," *The British Journal of Radiology*, 70, 130-139, 1997.

7. David Wiedis, Donald E. Jose, and Timm O. Phoebe, "The Rock and the Hard Place: Employer Liability to Fertile or Pregnant Employees and Their Unborn Children—What Can the Employer Do?" *Radiation Protection Management*, *11*, 41-49, January/February 1994.

8. National Council on Radiation Protection and Measurements, *Considerations Regarding the Unintended Radiation Exposure of the Embryo, Fetus, or Nursing Child*, NCRP Commentary No. 9, Bethesda, MD, 1994.

9. National Council on Radiation Protection and Measurements, *Risk Estimates for Radiation Protection*, NCRP Report No. 115, Bethesda, MD, 1993.

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[1]Single copies of regulatory guides, both active and draft, and draft NUREG documents may be obtained free of charge by writing the Reproduction and Distribution Services Section, OCIO, USNRC, Washington, DC 20555-0001, or by fax to (301)415-2289, or by email to <DISTRIBUTION@NRC.GOV>. Active guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161. Copies of active and draft guides are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343.

10. National Radiological Protection Board, *Advice on Exposure to Ionising Radiation During Pregnancy*, National Radiological Protection Board, Chilton, Didcot, UK, 1998.

11. M.L. Thomas and D. Hagemeyer, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1996," Twenty-Ninth Annual Report, NUREG-0713, Vol. 18, USNRC, 1998.[22]

[2]Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343.

FORM LETTER FOR DECLARING PREGNANCY

This form letter is provided for your convenience. To make your written declaration of pregnancy, you may fill in the blanks in this form letter, you may use a form letter the licensee has provided to you, or you may write your own letter.

DECLARATION OF PREGNANCY

To:_____

In accordance with the NRC's regulations at 10 CFR 20.1208, "Dose to an Embryo/Fetus," I am declaring that I am pregnant. I believe I became pregnant in_____ (only the month and year need be provided).

I understand the radiation dose to my embryo/fetus during my entire pregnancy will not be allowed to exceed 0.5 rem (5 millisievert) (unless that dose has already been exceeded between the time of conception and submitting this letter). I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

_____

(Your signature)

_____

(Your name printed)

_____

(Date)

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. A regulatory analysis prepared for 10 CFR Part 20, "Standards for Protection Against Radiation" (56 FR 23360), provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the "Regulatory Analysis for the Revision of 10 CFR Part 20" (PNL-6712, November 1988) is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW, Washington, DC, as an enclosure to Part 20 (56 FR 23360).

U.S. NUCLEAR REGULATORY COMMISSION

Revision 1
February 1996

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.29

(Draft was issued as DG-8012)

INSTRUCTION CONCERNING RISKS FROM OCCUPATIONAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12 of 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations," requires that all individuals who in the course of their employment are likely to receive in a year an occupational dose in excess of 100 mrem (1 mSv) be instructed in the health protection issues associated with exposure to radioactive materials or radiation. Section 20.1206 of 10 CFR Part 20, "Standards for Protection Against Radiation," requires that before a planned special exposure occurs the individuals involved are, among other things, to be informed of the estimated doses and associated risks.

This regulatory guide describes the information that should be provided to workers by licensees about health risks from occupational exposure. This revision conforms to the revision of 10 CFR Part 20 that became effective on June 20, 1991, to be implemented by licensees no later than January 1, 1994. The revision of 10 CFR Part 20 establishes new dose limits based on the effective dose equivalent (EDE), requires the summing of internal and external dose, establishes a requirement that licensees use procedures and engineering controls to the extent practicable to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA), provides for planned special exposures, establishes a dose limit for the embryo/fetus of an occupationally exposed declared pregnant woman, and explicitly states that Part 20 is not to be construed as limiting action that may be necessary to protect health and safety during emergencies.

Any information collection activities mentioned in this regulatory guide are contained as requirements in 10 CFR Part 19 or 10 CFR Part 20. These regulations provide the regulatory bases for this guide. The information collection requirements in 10 CFR Parts 19 and 20 have been cleared under OMB Clearance Nos. 3150-0044 and 3150-0014, respectively.

B. DISCUSSION

It is important to qualify the material presented in this guide with the following considerations.

The coefficient used in this guide for occupational radiation risk estimates, 4×10^{-4} health effects per rem, is based on data obtained at much higher doses and dose rates than those encountered by workers. The risk coefficient obtained at high doses and dose rates was reduced to account for the reduced effectiveness of lower doses and dose rates in producing the stochastic effects observed in studies of exposed humans.

The assumption of a linear extrapolation from the lowest doses at which effects are observable down to

the occupational range has considerable uncertainty. The report of the Committee on the Biological Effects of Ionizing Radiation (Ref. 1) states that

> "... departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the 100 mrem dose range. Thus, the possibility that there may be no risk from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero."

The issue of beneficial effects from low doses, or hormesis, in cellular systems is addressed by the United Nations Scientific Committee on the Effects of Atomic Radiation (Ref. 2). UNSCEAR states that "... it would be premature to conclude that cellular adaptive responses could convey possible beneficial effects to the organism that would outweigh the detrimental effects of exposures to low doses of low-LET radiation."

In the absence of scientific certainty regarding the relationship between low doses and health effects, and as a conservative assumption for radiation protection purposes, the scientific community generally assumes that any exposure to ionizing radiation can cause biological effects that may be harmful to the exposed person and that the magnitude or probability of these effects is directly proportional to the dose. These effects may be classified into three categories:

Somatic Effects: Physical effects occurring in the exposed person. These effects may be observable after a large or acute dose (e.g., 100 rems[1] (1 Sv) or more to the whole body in a few hours); or they may be effects such as cancer that may occur years after exposure to radiation.

Genetic Effects: Abnormalities that may occur in the future children of exposed individuals and in subsequent generations (genetic effects exceeding normal incidence have not been observed in any of the studies of human populations).

Teratogenic Effects: Effects such as cancer or congenital malformation that may be observed in children who were exposed during the fetal and embryonic stages of development (these effects have been observed from high, i.e., above 20 rems (0.2 Sv), acute exposures).

The normal incidence of effects from natural and manmade causes is significant. For example, approximately 20% of people die from various forms of cancer whether or not they ever receive occupational exposure to radiation. To avoid increasing the incidence of such biological effects, regulatory controls are imposed on occupational doses to adults and minors and on doses to the embryo/fetus from occupational exposures of declared pregnant women.

Radiation protection training for workers who are occupationally exposed to ionizing radiation is an essential component of any program designed to ensure compliance with NRC regulations. A clear understanding of what is presently known about the biological risks associated with exposure to radiation will result in more effective radiation protection training and should generate more interest on the part of the workers in complying with radiation protection standards. In addition, pregnant women and other occupationally exposed workers should have available to them relevant information on radiation risks to enable them to make informed decisions regarding the acceptance of these risks. It is intended that workers who receive this instruction will develop respect for the risks involved, rather than excessive fear or indifference.

C. REGULATORY POSITION

Instruction to workers performed in compliance with 10 CFR 19.12 should be given prior to occupational exposure and periodically thereafter. The frequency of retraining might range from annually for licensees with complex operations such as nuclear power plants, to every three years for licensees who possess, for example, only low-activity sealed sources. If a worker is to participate in a planned special exposure, the worker should be informed of the associated risks in compliance with 10 CFR 20.1206.

In providing instruction concerning health protection problems associated with exposure to radiation, all occupationally exposed workers and their supervisors should be given specific instruction on the risk of biological effects resulting from exposure to radiation. The extent of these instructions should be commensurate with the radiological risks present in the workplace.

The instruction should be presented orally, in printed form, or in any other effective communication media to workers and supervisors. The appendix to this guide provides useful information for demonstrating compliance with the training requirements in 10 CFR Parts 19 and 20. Individuals should be given an opportunity to discuss the information and to ask questions. Testing is recommended, and each trainee should be asked to acknowledge in writing that the instruction has been received and understood.

[1] In the International System of Units (SI), the rem is replaced by the sievert; 100 rems is equal to 1 sievert (Sv).

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant or licensee proposes acceptable alternative methods for complying with specified portions of the Commission's regulations, the guidance and instructional materials in this guide will be used in the evaluation of applications for new licenses, license renewals, and license amendments and for evaluating compliance with 10 CFR 19.12 and 10 CFR Part 20.

REFERENCES

1. National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiation*, Report of the Committee on the Biological Effects of Ionizing Radiation (BEIR V), National Academy Press, Washington, DC, 1990.
2. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), *Sources and Effects of Ionizing Radiation*, United Nations, New York, 1993.

APPENDIX

INSTRUCTION CONCERNING RISKS FROM OCCUPATIONAL RADIATION EXPOSURE

This instructional material is intended to provide the user with the best available information about the health risks from occupational exposure to ionizing radiation. Ionizing radiation consists of energy or small particles, such as gamma rays and beta and alpha particles, emitted from radioactive materials, which can cause chemical or physical damage when they deposit energy in living tissue. A question and answer format is used. Many of the questions or subjects were developed by the NRC staff in consultation with workers, union representatives, and licensee representatives experienced in radiation protection training.

This Revision 1 to Regulatory Guide 8.29 updates the material in the original guide on biological effects and risks and on typical occupational exposure. Additionally, it conforms to the revised 10 CFR Part 20, "Standards for Protection Against Radiation," which was required to be implemented by licensees no later than January 1, 1994. The information in this appendix is intended to help develop respect by workers for the risks associated with radiation, rather than unjustified fear or lack of concern. Additional guidance concerning other topics in radiation protection training is provided in other NRC regulatory guides.

1. What is meant by health risk?

A health risk is generally thought of as something that may endanger health. Scientists consider health risk to be the statistical probability or mathematical chance that personal injury, illness, or death may result from some action. Most people do not think about health risks in terms of mathematics. Instead, most of us consider the health risk of a particular action in terms of whether we believe that particular action will, or will not, cause us some harm. The intent of this appendix is to provide estimates of, and explain the bases for, the risk of injury, illness, or death from occupational radiation exposure. Risk can be quantified in terms of the probability of a health effect per unit of dose received.

When x-rays, gamma rays, and ionizing particles interact with living materials such as our bodies, they may deposit enough energy to cause biological damage. Radiation can cause several different types of events such as the very small physical displacement of molecules, changing a molecule to a different form, or ionization, which is the removal of electrons from atoms and molecules. When the quantity of radiation energy deposited in living tissue is high enough, biological damage can occur as a result of chemical bonds being broken and cells being damaged or killed. These effects can result in observable clinical symptoms.

The basic unit for measuring absorbed radiation is the rad. One rad (0.01 gray in the International System of units) equals the absorption of 100 ergs (a small but measurable amount of energy) in a gram of material such as tissue exposed to radiation. To reflect biological risk, rads must be converted to rems. The new international unit is the sievert (100 rems = 1 Sv). This conversion accounts for the differences in the effectiveness of different types of radiation in causing damage. The rem is used to estimate biological risk. For beta and gamma radiation, a rem is considered equal to a rad.

2. What are the possible health effects of exposure to radiation?

Health effects from exposure to radiation range from no effect at all to death, including diseases such as leukemia or bone, breast, and lung cancer. Very high (100s of rads), short-term doses of radiation have been known to cause prompt (or early) effects, such as vomiting and diarrhea,[1] skin burns, cataracts, and even death. It is suspected that radiation exposure may be linked to the potential for genetic effects in the children of exposed parents. Also, children who were exposed to high doses (20 or more rads) of radiation prior to birth (as an embryo/fetus) have shown an increased risk of mental retardation and other congenital malformations. These effects (with the exception of genetic effects) have been observed in various studies of medical radiologists, uranium miners, radium workers, radiotherapy patients, and the people exposed to radiation from atomic bombs dropped on Japan. In addition, radiation effects studies with laboratory animals, in which the animals were given relatively high doses, have provided extensive data on radiation-induced health effects, including genetic effects.

It is important to note that these kinds of health effects result from high doses, compared to occupational levels, delivered over a relatively short period of time.

Although studies have not shown a consistent cause-and-effect relationship between current levels of occupational radiation exposure and biological effects, it is prudent from a worker protection perspective to assume that some effects may occur.

[1]These symptoms are early indicators of what is referred to as the acute radiation syndrome, caused by high doses delivered over a short time period, which includes damage to the blood-forming organs such as bone marrow, damage to the gastrointestinal system, and, at very high doses, can include damage to the central nervous system.

3. What is meant by early effects and delayed or late effects?

EARLY EFFECTS

Early effects, which are also called immediate or prompt effects, are those that occur shortly after a large exposure that is delivered within hours to a few days. They are observable after receiving a very large dose in a short period of time, for example, 300 rads (3 Gy) received within a few minutes to a few days. Early effects are not caused at the levels of radiation exposure allowed under the NRC's occupational limits.

Early effects occur when the radiation dose is large enough to cause extensive biological damage to cells so that large numbers of cells are killed. For early effects to occur, this radiation dose must be received within a short time period. This type of dose is called an acute dose or acute exposure. The same dose received over a long time period would not cause the same effect. Our body's natural biological processes are constantly repairing damaged cells and replacing dead cells; if the cell damage is spread over time, our body is capable of repairing or replacing some of the damaged cells, reducing the observable adverse conditions.

For example, a dose to the whole body of about 300–500 rads (3–5 Gy), more than 60 times the annual occupational dose limit, if received within a short time period (e.g., a few hours) will cause vomiting and diarrhea within a few hours; loss of hair, fever, and weight loss within a few weeks; and about a 50 percent chance of death if medical treatment is not provided. These effects would not occur if the same dose were accumulated gradually over many weeks or months (Refs. 1 and 2). Thus, one of the justifications for establishing annual dose limits is to ensure that occupational dose is spread out in time.

It is important to distinguish between whole body and partial body exposure. A localized dose to a small volume of the body would not produce the same effect as a whole body dose of the same magnitude. For example, if only the hand were exposed, the effect would mainly be limited to the skin and underlying tissue of the hand. An acute dose of 400 to 600 rads (4–6 Gy) to the hand would cause skin reddening; recovery would occur over the following months and no long-term damage would be expected. An acute dose of this magnitude to the whole body could cause death within a short time without medical treatment. Medical treatment would lessen the magnitude of the effects and the chance of death; however, it would not totally eliminate the effects or the chance of death.

DELAYED EFFECTS

Delayed effects may occur years after exposure. These effects are caused indirectly when the radiation changes parts of the cells in the body, which causes the normal function of the cell to change, for example, normal healthy cells turn into cancer cells. The potential for these delayed health effects is one of the main concerns addressed when setting limits on occupational doses.

A delayed effect of special interest is genetic effects. Genetic effects may occur if there is radiation damage to the cells of the gonads (sperm or eggs). These effects may show up as genetic defects in the children of the exposed individual and succeeding generations. However, if any genetic effects (i.e., effects in addition to the normal expected number) have been caused by radiation, the numbers are too small to have been observed in human populations exposed to radiation. For example, the atomic bomb survivors (from Hiroshima and Nagasaki) have not shown any significant radiation-related increases in genetic defects (Ref. 3). Effects have been observed in animal studies conducted at very high levels of exposure and it is known that radiation can cause changes in the genes in cells of the human body. However, it is believed that by maintaining worker exposures below the NRC limits and consistent with ALARA, a margin of safety is provided such that the risk of genetic effects is almost eliminated.

4. What is the difference between acute and chronic radiation dose?

Acute radiation dose usually refers to a large dose of radiation received in a short period of time. Chronic dose refers to the sum of small doses received repeatedly over long time periods, for example, 20 mrem (or millirem, which is 1-thousandth of a rem) (0.2 mSv) per week every week for several years. It is assumed for radiation protection purposes that any radiation dose, either acute or chronic, may cause delayed effects. However, only large acute doses cause early effects; chronic doses within the occupational dose limits do not cause early effects. Since the NRC limits do not permit large acute doses, concern with occupational radiation risk is primarily focused on controlling chronic exposure for which possible delayed effects, such as cancer, are of concern.

The difference between acute and chronic radiation exposure can be shown by using exposure to the sun's rays as an example. An intense exposure to the sun can result in painful burning, peeling, and growing of new skin. However, repeated short exposures provide time for the skin to be repaired between exposures. Whether exposure to the sun's rays is long term or spread over short periods, some of the injury may not be repaired and may eventually result in skin cancer.

Cataracts are an interesting case because they can be caused by both acute and chronic radiation. A certain threshold level of dose to the lens of the eye is required before there is any observable visual impairment, and the impairment remains after the exposure is stopped. The threshold for cataract development

from acute exposure is an acute dose on the order of 100 rads (1 Gy). Further, a cumulative dose of 800 rads (8 Gy) from protracted exposures over many years to the lens of the eye has been linked to some level of visual impairment (Refs. 1 and 4). These doses exceed the amount that may be accumulated by the lens from normal occupational exposure under the current regulations.

5. What is meant by external and internal exposure?

A worker's occupational dose may be caused by exposure to radiation that originates outside the body, called "external exposure," or by exposure to radiation from radioactive material that has been taken into the body, called "internal exposure." Most NRC-licensed activities involve little, if any, internal exposure. It is the current scientific consensus that a rem of radiation dose has the same biological risk regardless of whether it is from an external or an internal source. The NRC requires that dose from external exposure and dose from internal exposure be added together, if each exceeds 10% of the annual limit, and that the total be within occupational limits. The sum of external and internal dose is called the total effective dose equivalent (TEDE) and is expressed in units of rems (Sv).

Although unlikely, radioactive materials may enter the body through breathing, eating, drinking, or open wounds, or they may be absorbed through the skin. The intake of radioactive materials by workers is generally due to breathing contaminated air. Radioactive materials may be present as fine dust or gases in the workplace atmosphere. The surfaces of equipment and workbenches may be contaminated, and these materials can be resuspended in air during work activities.

If any radioactive material enters the body, the material goes to various organs or is excreted, depending on the biochemistry of the material. Most radioisotopes are excreted from the body in a few days. For example, a fraction of any uranium taken into the body will deposit in the bones, where it remains for a longer time. Uranium is slowly eliminated from the body, mostly by way of the kidneys. Most workers are not exposed to uranium. Radioactive iodine is preferentially deposited in the thyroid gland, which is located in the neck.

To limit risk to specific organs and the total body, an annual limit on intake (ALI) has been established for each radionuclide. When more than one radionuclide is involved, the intake amount of each radionuclide is reduced proportionally. NRC regulations specify the concentrations of radioactive material in the air to which a worker may be exposed for 2,000 working hours in a year. These concentrations are termed the derived air concentrations (DACs). These limits are the total amounts allowed if no external radiation is received. The resulting dose from the internal radiation sources (from breathing air at 1 DAC) is the maximum allowed to an organ or to the worker's whole body.

6. How does radiation cause cancer?

The mechanisms of radiation-induced cancer are not completely understood. When radiation interacts with the cells of our bodies, a number of events can occur. The damaged cells can repair themselves and permanent damage is not caused. The cells can die, much like the large numbers of cells that die every day in our bodies, and be replaced through the normal biological processes. Or a change can occur in the cell's reproductive structure, the cells can mutate and subsequently be repaired without effect, or they can form precancerous cells, which may become cancerous. Radiation is only one of many agents with the potential for causing cancer, and cancer caused by radiation cannot be distinguished from cancer attributable to any other cause.

Radiobiologists have studied the relationship between large doses of radiation and cancer (Refs. 5 and 6). These studies indicate that damage or change to genes in the cell nucleus is the main cause of radiation-induced cancer. This damage may occur directly through the interaction of the ionizing radiation in the cell or indirectly through the actions of chemical products produced by radiation interactions within cells. Cells are able to repair most damage within hours; however, some cells may not be repaired properly. Such misrepaired damage is thought to be the origin of cancer, but misrepair does not always cause cancer. Some cell changes are benign or the cell may die; these changes do not lead to cancer.

Many factors such as age, general health, inherited traits, sex, as well as exposure to other cancer-causing agents such as cigarette smoke can affect susceptibility to the cancer-causing effects of radiation. Many diseases are caused by the interaction of several factors, and these interactions appear to increase the susceptibility to cancer.

7. Who developed radiation risk estimates?

Radiation risk estimates were developed by several national and international scientific organizations over the last 40 years. These organizations include the National Academy of Sciences (which has issued several reports from the Committee on the Biological Effects of Ionizing Radiations, BEIR), the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Each of these organizations continues to review new research findings on radiation health risks.

Several reports from these organizations present new findings on radiation risks based upon revised estimates of radiation dose to survivors of the atomic bombing at Hiroshima and Nagasaki. For example, UNSCEAR published risk estimates in 1988 and 1993 (Refs. 5 and 6). The NCRP also published a report in 1988, "New Dosimetry at Hiroshima and Nagasaki and Its Implications for Risk Estimates" (Ref. 7). In January 1990, the National Academy of Sciences released the fifth report of the BEIR Committee, "Health Effects of Exposure to Low Levels of Ionizing Radiation" (Ref. 4). Each of these publications also provides extensive bibliographies on other published studies concerning radiation health effects for those who may wish to read further on this subject.

8. What are the estimates of the risk of fatal cancer from radiation exposure?

We don't know exactly what the chances are of getting cancer from a low-level radiation dose, primarily because the few effects that may occur cannot be distinguished from normally occurring cancers. However, we can make estimates based on extrapolation from extensive knowledge from scientific research on high dose effects. The estimates of radiation effects at high doses are better known than are those of most chemical carcinogens (Ref. 8).

From currently available data, the NRC has adopted a risk value for an occupational dose of 1 rem (0.01 Sv) Total Effective Dose Equivalent (TEDE) of 4 in 10,000 of developing a fatal cancer, or approximately 1 chance in 2,500 of fatal cancer per rem of TEDE received. The uncertainty associated with this risk estimate does not rule out the possibility of higher risk, or the possibility that the risk may even be zero at low occupational doses and dose rates.

The radiation risk incurred by a worker depends on the amount of dose received. Under the linear model explained above, a worker who receives 5 rems (0.05 Sv) in a year incurs 10 times as much risk as another worker who receives only 0.5 rem (0.005 Sv). Only a very few workers receive doses near 5 rems (0.05 Sv) per year (Ref. 9).

According to the BEIR V report (Ref. 4), approximately one in five adults normally will die from cancer from all possible causes such as smoking, food, alcohol, drugs, air pollutants, natural background radiation, and inherited traits. Thus, in any group of 10,000 workers, we can estimate that about 2,000 (20%) will die from cancer without any occupational radiation exposure.

To explain the significance of these estimates, we will use as an example a group of 10,000 people, each exposed to 1 rem (0.01 Sv) of ionizing radiation. Using the risk factor of 4 effects per 10,000 rem of dose, we estimate that 4 of the 10,000 people might die from delayed cancer because of that 1-rem dose (although the actual number could be more or less than 4) in addition to the 2,000 normal cancer fatalities expected to occur in that group from all other causes. This means that a 1-rem (0.01 Sv) dose may increase an individual worker's chances of dying from cancer from 20 percent to 20.04 percent. If one's lifetime occupational dose is 10 rems, we could raise the estimate to 20.4 percent. A lifetime dose of 100 rems may increase chances of dying from cancer from 20 to 24 percent. The average measurable dose for radiation workers reported to the NRC was 0.31 rem (0.0031 Sv) for 1993 (Ref. 9). Today, very few workers ever accumulate 100 rems (1 Sv) in a working lifetime, and the average career dose of workers at NRC-licensed facilities is 1.5 rems (0.015 Sv), which represents an estimated increase from 20 to about 20.06 percent in the risk of dying from cancer.

It is important to understand the probability factors here. A similar question would be, "If you select one card from a full deck of cards, will you get the ace of spades?" This question cannot be answered with a simple yes or no. The best answer is that your chance is 1 in 52. However, if 1000 people each select one card from full decks, we can predict that about 20 of them will get an ace of spades. Each person will have 1 chance in 52 of drawing the ace of spades, but there is no way we can predict which persons will get that card. The issue is further complicated by the fact that in a drawing by 1000 people, we might get only 15 successes, and in another, perhaps 25 correct cards in 1000 draws. We can say that if you receive a radiation dose, you will have increased your chances of eventually developing cancer. It is assumed that the more radiation exposure you get, the more you increase your chances of cancer.

The normal chance of dying from cancer is about one in five for persons who have not received any occupational radiation dose. The additional chance of developing fatal cancer from an occupational exposure of 1 rem (0.01 Sv) is about the same as the chance of drawing any ace from a full deck of cards three times in a row. The additional chance of dying from cancer from an occupational exposure of 10 rem (0.1 Sv) is about equal to your chance of drawing two aces successively on the first two draws from a full deck of cards.

It is important to realize that these risk numbers are only estimates based on data for people and research animals exposed to high levels of radiation in short periods of time. There is still uncertainty with regard to estimates of radiation risk from low levels of exposure. Many difficulties are involved in designing research studies that can accurately measure the projected small increases in cancer cases that might be caused by low exposures to radiation as compared to the normal rate of cancer.

These estimates are considered by the NRC staff to be the best available for the worker to use to make an informed decision concerning acceptance of the risks associated with exposure to radiation. A worker who decides to accept this risk should try to keep exposure to radiation as low as is reasonably achievable (ALARA) to avoid unnecessary risk.

9. If I receive a radiation dose that is within occupational limits, will it cause me to get cancer?

Probably not. Based on the risk estimates previously discussed, the risk of cancer from doses below the occupational limits is believed to be small. Assessment of the cancer risks that may be associated with low doses of radiation are projected from data available at doses larger than 10 rems (0.1 Sv) (Ref. 3). For radiation protection purposes, these estimates are made using the straight line portion of the linear quadratic model (Curve 2 in Figure 1). We have data on cancer probabilities only for high doses, as shown by the solid line in Figure 1. Only in studies involving radiation doses above occupational limits are there dependable determinations of the risk of cancer, primarily because below the limits the effect is small compared to differences in the normal cancer incidence from year to year and place to place. The ICRP, NCRP, and other standards-setting organizations assume for radiation protection purposes that there is some risk, no matter how small the dose (Curves 1 and 2). Some scientists believe that the risk drops off to zero at some low dose (Curve 3), the threshold effect. The ICRP and NCRP endorse the linear quadratic model as a conservative means of assuring safety (Curve 2).

For regulatory purposes, the NRC uses the straight line portion of Curve 2, which shows the number of effects decreasing linearly as the dose decreases. Because the scientific evidence does not conclusively demonstrate whether there is or is not an effect at low doses, the NRC assumes for radiation protection purposes, that even small doses have some chance of causing cancer. Thus, a principle of radiation protection is to do more than merely meet the allowed regulatory limits; doses should be kept as low as is reasonably achievable (ALARA). This is as true for natural carcinogens such as sunlight and natural radiation as it is for those that are manmade, such as cigarette smoke, smog, and x-rays.

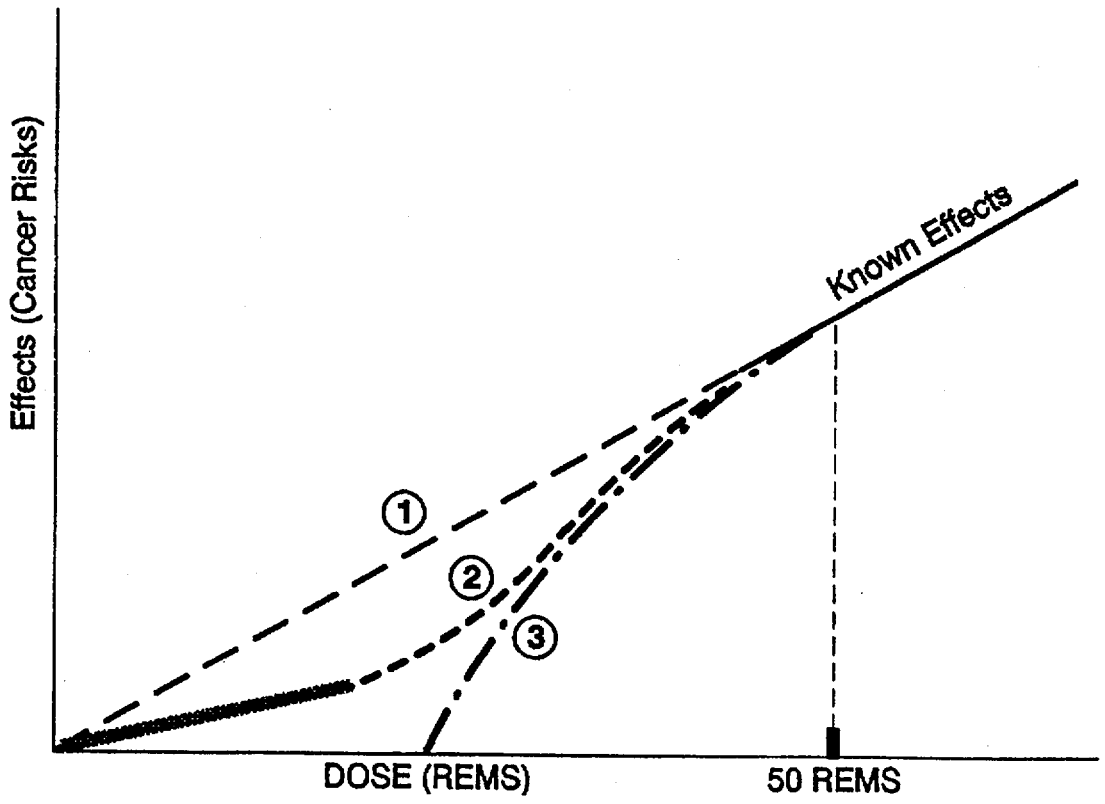

Figure 1. Some Proposed Models for How the Effects of Radiation Vary With Doses at Low Levels

10. How can we compare the risk of cancer from radiation to other kinds of health risks?

One way to make these comparisons is to compare the average number of days of life expectancy lost because of the effects associated with each particular health risk. Estimates are calculated by looking at a large number of persons, recording the age when death occurs from specific causes, and estimating the average number of days of life lost as a result of these early deaths. The total number of days of life lost is then averaged over the total observed group.

Several studies have compared the average days of life lost from exposure to radiation with the number of days lost as a result of being exposed to other health risks. The word "average" is important because an individual who gets cancer loses about 15 years of life expectancy, while his or her coworkers do not suffer any loss.

Some representative numbers are presented in Table 1. For categories of NRC-regulated industries with larger doses, the average measurable occupational dose in 1993 was 0.31 rem (0.0031 Sv). A simple calculation based on the article by Cohen and Lee (Ref. 10) shows that 0.3 rem (0.003 Sv) per year from age 18 to 65 results in an average loss of 15 days. These estimates indicate that the health risks from occupational radiation exposure are smaller than the risks associated with many other events or activities we encounter and accept in normal day-to-day activities.

It is also useful to compare the estimated average number of days of life lost from occupational exposure to radiation with the number of days lost as a result of working in several types of industries. Table 2 shows average days of life expectancy lost as a result of fatal work-related accidents. Table 2 does not include nonaccident types of occupational risks such as occupational disease and stress because the data are not available.

These comparisons are not ideal because we are comparing the possible effects of chronic exposure to radiation to different kinds of risk such as accidental death, in which death is inevitable if the event occurs. This is the best we can do because good data are not available on chronic exposure to other workplace carcinogens. Also, the estimates of loss of life expectancy for workers from radiation-induced cancer do not take into consideration the competing effect on the life expectancy of the workers from industrial accidents.

11. What are the health risks from radiation exposure to the embryo/fetus?

During certain stages of development, the embryo/fetus is believed to be more sensitive to radiation damage than adults. Studies of atomic bomb survivors exposed to acute radiation doses exceeding 20 rads (0.2 Gy) during pregnancy show that children born after receiving these doses have a higher risk of mental retardation. Other studies suggest that an association exists between exposure to diagnostic x-rays before birth and carcinogenic effects in childhood and in adult life. Scientists are uncertain about the magnitude of the risk. Some studies show the embryo/fetus to be more sensitive to radiation-induced cancer than adults, but other studies do not. In recognition of the possibility of increased radiation sensitivity, and because dose to the

Table 1 Estimated Loss of Life Expectancy from Health Risks[a]

Health Risk		*Estimate of Life Expectancy Lost (average)*
Smoking 20 cigarettes a day		6 years
Overweight (by 15%)		2 years
Alcohol consumption (U.S. average)		1 year
All accidents combined		1 year
Motor vehicle accidents	207 days	
Home accidents	74 days	
Drowning	24 days	
All natural hazards (earthquake, lightning, flood, etc.)		7 days
Medical radiation		6 days
Occupational Exposure		
0.3 rem/y from age 18 to 65	15 days	
1 rem/y from age 18 to 65	51 days	

[a]Adapted from Reference 10.

Table 2 Estimated Loss of Life Expectancy from Industrial Accidents[a]

Industry Type	*Estimated Days of Life Expectancy Lost (Average)*
All industries	60
Agriculture	320
Construction	227
Mining and Quarrying	167
Transportation and Public Utilities	160
Government	60
Manufacturing	40
Trade	27
Services	27

[a]Adapted from Reference 10.

embryo/fetus is involuntary on the part of the embryo/fetus, a more restrictive dose limit has been established for the embryo/fetus of a declared pregnant radiation worker. See Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure."

If an occupationally exposed woman declares her pregnancy in writing, she is subject to the more restrictive dose limits for the embryo/fetus during the remainder of the pregnancy. The dose limit of 500 mrems (5 mSv) for the total gestation period applies to the embryo/fetus and is controlled by restricting the exposure to the declared pregnant woman. Restricting the woman's occupational exposure, if she declares her pregnancy, raises questions about individual privacy rights, equal employment opportunities, and the possible loss of income. Because of these concerns, the declaration of pregnancy by a female radiation worker is voluntary. Also, the declaration of pregnancy can be withdrawn for any reason, for example, if the woman believes that her benefits from receiving the occupational exposure would outweigh the risk to her embryo/fetus from the radiation exposure.

12. Can a worker become sterile or impotent from normal occupational radiation exposure?

No. Temporary or permanent sterility cannot be caused by radiation at the levels allowed under NRC's occupational limits. There is a threshold below which these effects do not occur. Acute doses on the order of 10 rems (0.1 Sv) to the testes can result in a measurable but temporary reduction in sperm count. Temporary sterility (suppression of ovulation) has been observed in women who have received acute doses of 150 rads (1.5 Gy). The estimated threshold (acute) radiation dose for induction of permanent sterility is about 200 rads (2 Gy) for men and about 350 rads (3.5 Gy) for women (Refs. 1 and 4). These doses are far greater than the NRC s occupational dose limits for workers.

Although acute doses can affect fertility by reducing sperm count or suppressing ovulation, they do not have any direct effect on one's ability to function sexually. No evidence exists to suggest that exposures within the NRC's occupational limits have any effect on the ability to function sexually.

13. What are the NRC occupational dose limits?

For adults, an annual limit that does not exceed:

- 5 rems (0.05 Sv) for the total effective dose equivalent (TEDE), which is the sum of the deep dose equivalent (DDE) from external exposure to the whole body and the committed effective dose equivalent (CEDE) from intakes of radioactive material.
- 50 rems (0.5 Sv) for the total organ dose equivalent (TODE), which is the sum of the DDE from external exposure to the whole body and the committed dose equivalent (CDE) from intakes of radioactive material to any individual organ or tissue, other than the lens of the eye.
- 15 rems (0.15 Sv) for the lens dose equivalent (LDE), which is the external dose to the lens of the eye.
- 50 rems (0.5 Sv) for the shallow dose equivalent (SDE), which is the external dose to the skin or to any extremity.

For minor workers, the annual occupational dose limits are 10 percent of the dose limits for adult workers.

For protection of the embryo/fetus of a declared pregnant woman, the dose limit is 0.5 rem (5 mSv) during the entire pregnancy.

The occupational dose limit for adult workers of 5 rems (0.05 Sv) TEDE is based on consideration of the potential for delayed biological effects. The 5-rem (0.05 Sv) limit, together with application of the concept of keeping occupational doses ALARA, provides a level of risk of delayed effects considered acceptable by the NRC. The limits for individual organs are below the dose levels at which early biological effects are observed in the individual organs.

The dose limit for the embryo/fetus of a declared pregnant woman is based on a consideration of the possibility of greater sensitivity to radiation of the embryo/fetus and the involuntary nature of the exposure.

14. What is meant by ALARA?

ALARA means "as low as is reasonably achievable." In addition to providing an upper limit on an individual's permissible radiation dose, the NRC requires that its licensees establish radiation protection

programs and use procedures and engineering controls to achieve occupational doses, and doses to the public, as far below the limits as is reasonably achievable. "Reasonably achievable" also means "to the extent practicable." What is practicable depends on the purpose of the job, the state of technology, the costs for averting doses, and the benefits. Although implementation of the ALARA principle is a required integral part of each licensee's radiation protection program, it does not mean that each radiation exposure must be kept to an absolute minimum, but rather that "reasonable" efforts must be made to avert dose. In practice, ALARA includes planning tasks involving radiation exposure so as to reduce dose to individual workers and the work group.

There are several ways to control radiation doses, e.g., limiting the time in radiation areas, maintaining distance from sources of radiation, and providing shielding of radiation sources to reduce dose. The use of engineering controls, from the design of facilities and equipment to the actual set-up and conduct of work activities, is also an important element of the ALARA concept.

An ALARA analysis should be used in determining whether the use of respiratory protection is advisable. In evaluating whether or not to use respirators, the goal should be to achieve the optimal sum of external and internal doses. For example, the use of respirators can lead to increased work time within radiation areas, which increases external dose. The advantage of using respirators to reduce internal exposure must be evaluated against the increased external exposure and related stresses caused by the use of respirators. Heat stress, reduced visibility, and reduced communication associated with the use of respirators could expose a worker to far greater risks than are associated with the internal dose avoided by use of the respirator. To the extent practical, engineering controls, such as containments and ventilation systems, should be used to reduce workplace airborne radioactive materials.

15. What are background radiation exposures?

The average person is constantly exposed to ionizing radiation from several sources. Our environment and even the human body contain naturally occurring radioactive materials (e.g., potassium-40) that contribute to the radiation dose that we receive. The largest source of natural background radiation exposure is terrestrial radon, a colorless, odorless, chemically inert gas, which causes about 55 percent of our average, nonoccupational exposure. Cosmic radiation originating in space contributes additional exposure. The use of x-rays and radioactive materials in medicine and dentistry adds to our population exposure. As shown below in Table 3, the average person receives an annual radiation dose of about 0.36 rem (3.6 mSv). By age 20, the average person will accumulate over 7 rems (70 mSv) of dose. By age 50, the total dose is up to 18 rems (180 mSv). After 70 years of exposure this dose is up to 25 rems (250 mSv).

Table 3 Average Annual Effective Dose Equivalent to Individuals in the U.S.[a]

Source	*Effective Dose Equivalent (mrems)*	
Natural		
Radon	200	
Other than Radon	100	
Total		300
Nuclear Fuel Cycle		0.05
Consumer Products[b]		9
Medical		
Diagnostic X-rays	39	
Nuclear Medicine	14	
Total		53
Total		about 360 mrems/year

[a]Adapted from Table 8.1, NCRP 93 (Ref. 11).

[b]Includes building material, television receivers, luminous watches, smoke detectors, etc. (from Table 5.1, NCRP 93, Ref. 11).

16. What are the typical radiation doses received by workers?

For 1993, the NRC received reports on about a quarter of a million people who were monitored for occupational exposure to radiation. Almost half of those monitored had no measurable doses. The other half had an average dose of about 310 mrem (3.1 mSv) for the year. Of these, 93 percent received an annual dose of less than 1 rem (10 mSv); 98.7 percent received less than 2 rems (20 mSv); and the highest reported dose was for two individuals who each received between 5 and 6 rems (50 and 60 mSv).

Table 4 lists average occupational doses for workers (persons who had measurable doses) in various occupations based on 1993 data. It is important to note that beginning in 1994, licensees have been required to sum external and internal doses and certain licensees are required to submit annual reports. Certain types of licensees such as nuclear fuel fabricators may report a significant increase in worker doses because of the exposure to long-lived airborne radionuclides and the requirement to add the resultant internal dose to the calculation of occupational doses.

Table 4 Reported Occupational Doses for 1993[a]

Occupational Subgroup	Average Measurable Dose per Worker (millirems)
Industrial Radiography	540
Commercial Nuclear Power Reactors	310
Manufacturing and Distribution of Radioactive Materials	300
Low-Level Radioactive Waste Disposal	270
Independent Spent Nuclear Fuel Storage	260
Nuclear Fuel Fabrication	130

[a]From Table 3.1 in NUREG–0713 (Ref. 9).

17. How do I know how much my occupational dose (exposure) is?

If you are likely to receive more than 10 percent of the annual dose limits, the NRC requires your employer, the NRC licensee, to monitor your dose, to maintain records of your dose, and, at least on an annual basis for the types of licensees listed in 10 CFR 20.2206, "Reports of Individual Monitoring," to inform both you and the NRC of your dose. The purpose of this monitoring and reporting is so that the NRC can be sure that licensees are complying with the occupational dose limits and the ALARA principle.

External exposures are monitored by using individual monitoring devices. These devices are required to be used if it appears likely that external exposure will exceed 10 percent of the allowed annual dose, i.e., 0.5 rem (5 mSv). The most commonly used monitoring devices are film badges, thermoluminescence dosimeters (TLDs), electronic dosimeters, and direct reading pocket dosimeters.

With respect to internal exposure, your employer is required to monitor your occupational intake of radioactive material and assess the resulting dose if it appears likely that you will receive greater than 10 percent of the annual limit on intake (ALI) from intakes in 1 year. Internal exposure can be estimated by measuring the radiation emitted from the body (for example, with a "whole body counter") or by measuring the radioactive materials contained in biological samples such as urine or feces. Dose estimates can also be made if one knows how much radioactive material was in the air and the length of time during which the air was breathed.

18. What happens if a worker exceeds the annual dose limit?

If a worker receives a dose in excess of any of the annual dose limits, the regulations prohibit any occupational exposure during the remainder of the year in which the limit is exceeded. The licensee is also required to file an overexposure report with the NRC and provide a copy to the individual who received the dose. The licensee may be subject to NRC enforcement action such as a fine (civil penalty), just as individuals are subject to a traffic fine for exceeding a speed limit. The fines and, in some serious or repetitive cases, suspension of a license are intended to encourage licensees to comply with the regulations.

Radiation protection limits do not define safe or unsafe levels of radiation exposure. Exceeding a limit does not mean that you will get cancer. For radiation protection purposes, it is assumed that risks are related to the size of the radiation dose. Therefore, when your dose is higher your risk is also considered to be higher. These limits are similar to highway speed limits. If you drive at 70 mph, your risk is higher than at 55 mph, even though you may not actually have an accident. Those who set speed limits have determined that the risks of driving in excess of the speed limit are not acceptable. In the same way, the revised 10 CFR Part 20 establishes a limit for normal occupational exposure of 5 rems (0.05 Sv) a year. Although you will not necessarily get cancer or some other radiation effect at doses above the limit, it does mean that the licensee's safety program has failed in some way. Investigation is warranted to determine the cause and correct the conditions leading to the dose in excess of the limit.

19. What is meant by a "planned special exposure"?

A "planned special exposure" (PSE) is an infrequent exposure to radiation, separate from and in addition to the radiation received under the annual occupational limits. The licensee can authorize additional dose in any one year that is equal to the annual occupational dose limit as long as the individual's total dose from PSEs does not exceed five times the annual dose limit during the individual's lifetime. For example, licensees may authorize PSEs for an adult radiation worker to receive doses up to an additional 5 rems (0.05 Sv) in a year above the 5-rem (0.05–Sv) annual TEDE occupational dose limit. Each worker is limited to no more than 25 rems (0.25 Sv) from planned special exposures in his or her lifetime. Such exposures are only allowed in exceptional situations when alternatives for avoiding the additional exposure are not available or are impractical.

Before the licensee authorizes a PSE, the licensee must ensure that the worker is informed of the purpose and circumstances of the planned operation, the estimated doses expected, and the procedures to keep the doses ALARA while considering other risks that may

be present. (See Regulatory Guide 8.35, "Planned Special Exposures.")

20. Why do some facilities establish administrative control levels that are below the NRC limits?

There are two reasons. First, the NRC regulations state that licensees must take steps to keep exposures to radiation ALARA. Specific approval from the licensee for workers to receive doses in excess of administrative limits usually results in more critical risk-benefit analyses as each additional increment of dose is approved for a worker. Secondly, an administrative control level that is set lower than the NRC limit provides a safety margin designed to help the licensee avoid doses to workers in excess of the limit.

21. Why aren't medical exposures considered as part of a worker's allowed dose?

NRC rules exempt medical exposure, but equal doses of medical and occupational radiation have equal risks. Medical exposure to radiation is justified for reasons that are quite different from the reasons for occupational exposure. A physician prescribing an x-ray, for example, makes a medical judgment that the benefit to the patient from the resulting medical information justifies the risk associated with the radiation. This judgment may or may not be accepted by the patient. Similarly, each worker must decide on the benefits and acceptability of occupational radiation risk, just as each worker must decide on the acceptability of any other occupational hazard.

Consider a worker who receives a dose of 3 rems (0.03 Sv) from a series of x-rays in connection with an injury or illness. This dose and any associated risk must be justified on medical grounds. If the worker had also received 2 rems (0.02 Sv) on the job, the combined dose of 5 rems (0.05 Sv) would in no way incapacitate the worker. Restricting the worker from additional job exposure during the remainder of the year would not have any effect on the risk from the 3 rems (0.03 Sv) already received from the medical exposure. If the individual worker accepts the risks associated with the x-rays on the basis of the medical benefits and accepts the risks associated with job-related exposure on the basis of employment benefits, it would be unreasonable to restrict the worker from employment involving exposure to radiation for the remainder of the year.

22. How should radiation risks be considered in an emergency?

Emergencies are "unplanned" events in which actions to save lives or property may warrant additional doses for which no particular limit applies. The revised 10 CFR Part 20 does not set any dose limits for emergency or lifesaving activities and states that nothing in Part 20 "shall be construed as limiting actions that may be necessary to protect health and safety."

Rare situations may occur in which a dose in excess of occupational limits would be unavoidable in order to carry out a lifesaving operation or to avoid a large dose to large populations. However, persons called upon to undertake any emergency operation should do so only on a voluntary basis and with full awareness of the risks involved.

For perspective, the Environmental Protection Agency (EPA) has published emergency dose guidelines (Ref. 2). These guidelines state that doses to all workers during emergencies should, to the extent practicable, be limited to 5 rems (0.05 Sv). The EPA further states that there are some emergency situations for which higher limits may be justified. The dose resulting from such emergency exposures should be limited to 10 rems (0.1 Sv) for protecting valuable property, and to 25 rems (0.25 Sv) for lifesaving activities and the protection of large populations. In the context of this guidance, the dose to workers that is incurred for the protection of large populations might be considered justified for situations in which the collective dose to others that is avoided as a result of the emergency operation is significantly larger than that incurred by the workers involved.

Table 5 presents the estimates of the fatal cancer risk for a group of 1,000 workers of various ages, assuming that each worker received an acute dose of 25 rems (0.25 Sv) in the course of assisting in an emergency. The estimates show that a 25-rem emergency dose might increase an individual's chances of developing fatal cancer from about 20% to about 21%.

Table 5
Risk of Premature Death from Exposure to 25-Rems (0.25-Sv) Acute Dose

Age at Exposure (years)	*Estimated Risk of Premature Death (Deaths per 1,000 Persons Exposed)*
20–30	9.1
30–40	7.2
40–50	5.3
50–60	3.5

Source: EPA–400–R–92–001 (Ref. 2).

23. How were radiation dose limits established?

The NRC radiation dose limits in 10 CFR Part 20 were established by the NRC based on the recommendations of the ICRP and NCRP as endorsed in Federal radiation protection guidance developed by the EPA

(Ref. 12). The limits were recommended by the ICRP and NCRP with the objective of ensuring that working in a radiation-related industry was as safe as working in other comparable industries. The dose limits and the principle of ALARA should ensure that risks to workers are maintained indistinguishable from risks from background radiation.

24. Several scientific reports have recommended that the NRC establish lower dose limits. Does the NRC plan to reduce the regulatory limits?

Since publication of the NRC's proposed rule in 1986, the ICRP in 1990 revised its recommendations for radiation protection based on newer studies of radiation risks (Ref. 13), and the NCRP followed with a revision to its recommendations in 1993. The ICRP recommended a limit of 10 rems (0.1 Sv) effective dose equivalent (from internal and external sources), over a 5-year period with no more than 5 rems (0.05 Sv) in 1 year (Ref. 13). The NCRP recommended a cumulative limit in rems, not to exceed the individual's age in years, with no more than 5 rems (0.05 Sv) in any year (Ref. 14).

The NRC does not believe that additional reductions in the dose limits are required at this time. Because of the practice of maintaining radiation exposures ALARA (as low as is reasonably achievable), the average radiation dose to occupationally exposed persons is well below the limits in the current Part 20 that became mandatory January 1, 1994, and the average doses to radiation workers are below the new limits recommended by the ICRP and the NCRP.

25. What are the options if a worker decides that the risks associated with occupational radiation exposure are too high?

If the risks from exposure to occupational radiation are unacceptable to a worker, he or she can request a transfer to a job that does not involve exposure to radiation. However, the risks associated with the exposure to radiation that workers, on the average, actually receive are comparable to risks in other industries and are considered acceptable by the scientific groups that have studied them. An employer is not obligated to guarantee a transfer if a worker decides not to accept an assignment that requires exposure to radiation.

Any worker has the option of seeking other employment in a nonradiation occupation. However, the studies that have compared occupational risks in the nuclear industry to those in other job areas indicate that nuclear work is relatively safe. Thus, a worker may find different kinds of risk but will not necessarily find significantly lower risks in another job.

26. Where can one get additional information on radiation risk?

The following list suggests sources of useful information on radiation risk:

- The employer—the radiation protection or health physics office where a worker is employed.
- Nuclear Regulatory Commission Regional Offices:

King of Prussia, Pennsylvania	(610) 337–5000
Atlanta, Georgia	(404) 331–4503
Lisle, Illinois	(708) 829–9500
Arlington, Texas	(817) 860–8100

- U.S. Nuclear Regulatory Commission
  Headquarters
  Radiation Protection & Health Effects Branch
  Office of Nuclear Regulatory Research
  Washington, DC 20555
  Telephone: (301) 415–6187
- Department of Health and Human Services
  Center for Devices and Radiological Health
  1390 Piccard Drive, MS HFZ–1
  Rockville, MD 20850
  Telephone: (301) 443–4690
- U.S. Environmental Protection Agency
  Office of Radiation and Indoor Air
  Criteria and Standards Division
  401 M Street NW.
  Washington, DC 20460
  Telephone: (202) 233–9290

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*Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202) 634-3273; fax (202) 634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202) 512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

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[2]Single copies of regulatory guides may be obtained free of charge by writing the Office of Administration, Attn: Distribution and Services Section, USNRC, Washington, DC 20555, or by fax at (301) 415-2260. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555-0001; telephone (202) 634-3273; fax (202) 634-3343.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this Revision 1 to Regulatory Guide 8.29. A value/impact statement, which evaluated essentially the same subjects as are discussed in a regulatory analysis, accompanied Regulatory Guide 8.29 when it was issued in July 1981.

This Revision 1 to Regulatory Guide 8.29 is needed to conform with the Revised 10 CFR Part 20, "Standards for Protection Against Radiation," as published May 21, 1991 (56 FR 23360). The regulatory analysis prepared for 10 CFR Part 20 provides the regulatory basis for this Revision 1 of Regulatory Guide 8.29, and it examines the costs and benefits of the rule as implemented by the guide. A copy of the "Regulatory Analysis for the Revision of 10 CFR Part 20" (PNL–6712, November 1988), is available for inspection and copying for a fee in the NRC's Public Document Room at 2120 L Street NW., Washington, DC 20555–0001.

End of Radiation Safety Guide. Revision approved by Rutgers University's RSC on 7/31/2025.

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