

RADIATION SAFETY USERS GUIDE



UNIVERSITY *of* NEW HAMPSHIRE

OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY

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RADIATION SAFETY USERS GUIDE

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1. CONTACT INFORMATION AND EMERGENCY PROCEDURES

In any emergency, always quickly assess the situation to determine the extent of the crisis and whether or not there are injured people who require medical attention. Reference the University of New Hampshire (UNH) Emergency Procedures Program for additional information.

If people are injured or there is a fire:



Call 9-1-1

Durham Fire Department	862-1426
Wentworth Douglas Hospital (Dover)	742-5252
Portsmouth Regional Hospital (Portsmouth)	436-5110

In the event of a Radioactive Materials Spill or accident:

Radiation Safety Officer	862-3607 (Office)
	312-2500 (Cell)
Environmental Health and Safety Office	862-4041
New Hampshire Radiological Health Section	271-4588
After Hours Radiological Health Section Contact	800-852-3411

General Contact Information:

Radiation Safety Officer	862-3607
EHS Office	862-4041
EHS Director	862-2571

NOTE: To check on a pending permit application, radioactive materials order, upcoming training classes or other radiation safety related information please contact the Radiation Safety Officer.



REMINDER:

Treat Injuries First!
If you require First Aid
or Medical Assistance –

Call 911 !

EMERGENCY PROCEDURES

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FOR MINOR SPILLS OF RADIOACTIVE MATERIALS

Call the Radiation Safety Officer if any of the following is true:

- (1) Contamination on skin or clothing;
- (2) Activity of the spill is greater than 10 μ Ci;
- (3) The spill is outside of the immediate work area;
- (4) The spill covers a large area or volume.

Instructions to Workers:

- Use SWIMS!
- **S** - Stop the spill and stop what you're doing (stop your research). Cover the spill with absorbent paper (dampened if spilled material is solid).
- **W** - Warn others in the area. They may not be contaminated and need to know.
- **I** - Isolate the area so others don't get contaminated. Use rad tape or ribbon if possible.
- **M** - Monitor for skin contamination and clothing contamination. Change gloves often.
- **S** - Survey and cleanup the contaminated area. Do not forget your dosimeter or the proper protection equipment: gloves, laboratory coat, eye protection, and booties (shoe coverings) before attempting to clean the spill. Mark the perimeter of the spill and isolated spots. Thoroughly clean by wiping the contamination with absorbent paper (preferably with Radiacwash or Count-off) working from the perimeter towards the center of the spill.
- **REMEMBER**, used radioactive absorbent paper must be disposed of in the respective radioisotopes' waste container (i.e. ³²P waste goes in ³²P container, etc). Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to the proper waste container. Put contaminated gloves and any other contaminated disposable material in the bag.
- Once finished with the decontamination, survey the area to make sure that it is reading background levels. Perform an extensive personnel survey. Take your time in surveying the hands, shoes, laboratory coat, pants, and face.
- Do not allow personnel to return to work until area is cleared by the RSO.

EMERGENCY PROCEDURES

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FOR MAJOR SPILLS OF RADIOACTIVE MATERIAL

Major spills are defined as any accident involving radioactive materials resulting in one or more of the following situations:

- (1) Radioactive material greater than or equal to one millicurie is involved;
- (2) Radioactive liquids greater than one liter are involved;
- (3) Any personnel contamination;
- (4) Any contamination in unrestricted areas;
- (5) Multiple findings of contamination within a restricted area.

Instructions to Workers:

- Clear the area. If appropriate, survey all persons not involved in the spill and vacate the room.
- Prevent the spread of contamination by covering the spill with absorbent paper (paper should be dampened if solids are spilled), but do not attempt to clean it up. To prevent the spread of contamination, limit the movement of all personnel who may be contaminated.
- Shield the source only if it can be done without further contamination or significant increase in radiation exposure.
- Close the room and lock or otherwise secure the area to prevent entry. Post the room with a sign to warn anyone trying to enter that a spill of radioactive material has occurred.
- Notify the Radiation Safety Officer (RSO) immediately.
- Survey all personnel who could possibly have been contaminated. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and then washing with a mild soap.
- Allow no one to return to work in the area unless approved by the RSO.
- Cooperate with RSO/Radiation Safety staff (e.g., investigation of root cause, provision of requested bioassay samples).
- Follow the instructions of the RSO/Radiation Safety staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

2. INTRODUCTION

The University of New Hampshire (UNH) uses radioactive materials in the pursuit of research and education in accordance with a Radioactive Materials License issued by the State of New Hampshire's Radiological Health Section. In support of this license, UNH has created a comprehensive Radiation Protection Program (RPP). This program is available for review online at <http://www.unh.edu/ehs/radsafety/RPP.pdf> and a copy of UNH's radioactive materials license is available for your review at the Office of Environmental Health and Safety located in Perpetuity Hall at 11 Leavitt Lane. Many elements of the RPP are reproduced in this Users Guide.

The University of New Hampshire (UNH) has committed to maintaining a Radiation Protection Program (RPP) of the highest quality. Likewise, UNH has committed to full and complete compliance with all relevant requirements in New Hampshire Rules For The Control Of Radiation. The Radiation Protection Program is designed to control operations conducted at the UNH Research and Education Facilities that may result in the potential exposure of UNH personnel, students, members of the general public and/or the environment to ionizing radiation. The University of New Hampshire's commitment to the RPP is based on the fundamental principle that levels of radioactivity to be used, and exposures to all sources of ionizing radiation, are to be maintained **As Low As Reasonably Achievable (ALARA)**.

3. ORGANIZATION OF THE RADIATION SAFETY PROGRAM

The Radiation Protection Program at UNH has been organized to allow a system of competent peer review of all activities, procedures and policies involving ionizing radiation. This peer review process is directed by the Radiation Safety Committee (RSC), which is charged with oversight of the Radiation Protection Program. The Radiation Safety Officer (RSO) is the individual responsible for the implementation of the RPP and reports to the RSC. Authorized Users (AUs) are those individuals who, based on training and experience, have received approval from the Radiation Safety Committee to oversee the usage of radioactive materials. Individuals who use radioactivity at UNH are termed Radiation Workers and follow the guidance of the RSC as implemented by the RSO and AUs.

3.1 Radiation Safety Committee (RSC)

The Radiation Safety Committee meets at least quarterly to discuss and review issues concerning radiation safety at UNH. The Committee has a number of charges including oversight of the Radiation Safety Officer (RSO) and approval of Radioactive Material Users Permits for researchers. The Committee is comprised of a sampling of knowledgeable faculty members and departmental representatives. A schedule of the RSC meetings may be obtained from the Radiation Safety Officer.

3.2 Radiation Safety Officer (RSO)

The Radiation Safety Officer is the individual specifically approved by the State of New Hampshire to implement the Radiation Protection Program and is the primary radiation safety resource to the UNH community. The RSO and his support staff work in the Office of Environmental Health and Safety (OEHS) and report to the Director of OEHS.

The RSO brings issues of compliance, efficiency and safety to the attention of the RSC for resolution.

3.3 Authorized Users (AU)

Authorized Users are those faculty or staff members who have attained sufficient experience in using or designing protocols for the use of radioactive materials so as to receive approval from the Radiation Safety Committee to oversee such procedures at UNH.

3.4 Radiation Workers

The majority of individuals who handle or manipulate radioactive materials at UNH will fall into this designation. Radiation Workers use radioactive materials under a Permit approved by the RSC. This permit details the types and quantities of radioactive material allowed and the procedural detail of how to safely use the material. In order to qualify as a Radiation Worker, individuals must follow the requirements set forth in the Radiation Protection Program (see Sections 4 and 5 in this Guide).

4. YOUR RIGHTS AND RESPONSIBILITIES

As a Radiation Worker and user of radioactive materials at UNH, there are certain rights afforded you and responsibilities required of you. These rights and responsibilities will be clearly detailed in the required training that you will complete. A summary listing is included for your convenience:

- You have the right to a safe work environment.
- You have the right to review documents relating to the UNH radiation safety program including the Radioactive Materials License, Radiation Protection Program and any Permit under which you perform work with radioactivity.
- You have the right to review your exposure records.
- You have the right to discuss any compliance concerns with your supervisor, the RSO and/or the State of New Hampshire Radiological Health Section without fear of reprisal for your job.

⇒ **Remember you can review a copy of the UNH Radioactive Materials License and Radiation Protection Program in OEHS**

Your responsibilities include:

- Keep exposures to ionizing radiation As Low As Reasonably Achievable (ALARA).
- Conduct a hand frisk survey prior to exiting a restricted area (when applicable) or whenever contamination is suspected.
- Wear the proper personal protective equipment (PPE) when working with or handling radioactive materials (i.e. laboratory coats and latex gloves). PPE should not be worn outside of controlled areas.
- There will be no eating, drinking, smoking, chewing gum, eating utensils or application of cosmetics in areas under radiological control. No evidence of the aforementioned activities will be discarded into trash receptacles in controlled areas.
- Maintain good personal hygiene. Wash hands and wrists thoroughly after exiting an area under radiological control.

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- Use double gloves when working with radioactive materials if there is an abrasion of the skin below the wrist.
- Survey the work area for radioactive contamination upon completion of work involving radioactive material in unsealed form. Contaminated areas must be decontaminated immediately.
- All radioactive samples, contaminated equipment and waste containers will be appropriately labeled.
- The RSO, or designee, will be immediately notified of any personnel contamination, internal exposure or a major spill involving radioactive materials.
- Report all findings during contamination surveys in units of radioactivity (e.g. dpm or microcuries).
- Report all evidence of non-compliance to the RSO, RSC or State of New Hampshire Radiological Health Section.

5. USING RADIOACTIVE MATERIALS AT UNH

In order to use radioactive materials at UNH, you must first be qualified as a Radiation Worker and be included as an approved user on a valid Radioactive Material Users Permit. This process includes administrative processing, training, dosimetry and bioassay, permit and lab policy review and orientation.

5.1 Administrative Processing

Whether or not this is the first time that you have used radioactive materials, some administrative paperwork is required. You can help expedite this process by providing the needed documentation in a timely fashion. First, your Principal Investigator (PI), or you if you are a PI, must decide that you will be using radioactive materials. If this use is currently ongoing, then you will need to be added to the Radioactive Material Users Permit as an approved Radiation Worker via a Permit amendment. If this is new work, then the Radioactive Material Users Permit will need to be amended and the new protocol would need to be submitted to the RSO for review and then submitted to the RSC for approval.

You will need to complete a prior work history questionnaire as part of your Radiation Worker registration with the Radiation Safety Officer. This questionnaire is used to determine whether or not you have had occupational radiation exposure and to request the transfer of any pertinent occupational records from previous employers. Based on this questionnaire, additional information may be required should your Permit require bioassay and/or dosimetry monitoring.

5.2 Training

All Radiation Workers are required to successfully complete initial and recurrent radiation safety training. This training includes an introduction to radiation protection principles, the UNH Radiation Protection Program, the bioeffects of ionizing radiation exposure and other topics relevant to radiation safety program management. Radiation Workers are required to complete the initial training prior to working with radioactive materials.

As a rule, Radiation Safety training will be required:

1. Before assuming duties with, or working in a radioactive material posted lab;
2. Whenever there is a significant change in duties, regulations, or the terms of the license;
3. Annually (refresher training).

In order to meet function specific training requirements, the following types of training are offered by the Radiation Safety Officer:

1. Ancillary Personnel Radiation Awareness Training, Initial
2. Radiation Worker Training, Initial
3. Ancillary Personnel Radiation Awareness Training, Refresher
4. Radiation Worker Training, Refresher
5. Contractor Radiation Awareness Training

Ancillary Personnel training is intended to provide adequate instruction to those University employees who during the course of their job duties work in areas where radioactive materials are used or stored. They are not to handle any radioactive materials.

Contractor Radiation Safety Awareness training is intended to provide adequate instruction to those non-University employees who during the course of their job duties work in areas (or on equipment) where radioactive materials are used or stored. They are not to handle any radioactive materials. Note: Contractors cannot work on equipment that has radioactive components or equipment that may be contaminated.

All training classes require a competency evaluation. Information regarding the schedule of classes, course outlines and required attendance can be obtained from the Radiation Safety Officer.

5.3 Dosimetry and Bioassay

Radiation Workers may be required to participate in dosimetry or bioassay monitoring programs. This determination is made by the RSO and RSC during the review and approval of Radioactive Material Use Permits. If dosimetry or bioassay monitoring is required, a schedule of dosimeter exchange and/or sample collection dates will be made available.

Annual reports of personal exposure will be made available as required by New Hampshire regulations. However, any request to review your personal exposure history will be granted if made to the Radiation Safety Officer in writing.

5.4 Permit Review and Lab Orientation

Though this guide seeks to provide you with as much information regarding the use of radioactive materials at UNH as is possible, you should be aware that the specifics of individual Radioactive Material Users Permits are not discussed herein. Rather, this guide is meant as an

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overview for general policy and should be supplemented by your review of the Permits under which you expect to work. In addition, you should review the Permit and any other applicable lab policies or safety procedures that may apply. This Lab Orientation is a critical part of your understanding your work environment and the expectations of those working in that environment.

6. ORDERING RADIOACTIVE MATERIALS

As a rule, only Authorized Users and Radiation Workers in good standing who are working under a valid Radioactive Material Users Permit may order radioactive materials. All radioactive material orders must be approved by the Radiation Safety Office *prior to the placement of the order*. These requirements are in place to assure that UNH meets its inventory control and possession limit requirements.

To begin the procurement process, complete a purchase request form found online at the EHS website and obtain the required departmental approval. Forward the purchase request form to your respective Business Service Center, who will then fax the form with PO number to the Radiation Safety Officer for approval. Please allow at least 24 hours for Radiation Safety Officer approval. The Radiation Safety Officer will assure that the material you are requesting is within our license limitations and is appropriate for your Permit. The RSO, or designee, will complete the order with the vendor once this approval is complete.

All radioactive material packages are to be sent to the Radiation Safety Officer for survey and subsequent delivery to your lab. Be certain to have all packages sent to:

**Attn: Radiation Safety Officer
University of New Hampshire
Office of Environmental Health and Safety
Perpetuity Hall, 11 Leavitt Lane
Durham, NH 03824**

The RSO, or designee, will complete initial quality assurance and contamination surveys on the package and deliver the materials to your lab. Please be certain to inform the RSO of any temperature sensitivity requirements, special delivery considerations or temporary storage requirements.

7. INVENTORY AND SURVEYING REQUIREMENTS

Once a shipment of radioactive materials is received in your lab, the responsibility for tracking the material falls to you. This is accomplished by completing a Radioactive Materials Inventory Form. This simple form requires you to record each withdrawal of material from the source vial until the material is completely used or no longer needed and transferred to radioactive waste.

Once the form is complete and the material has been completely exhausted or transferred to waste, retain the form in your records for future review. The Radiation Safety Officer will use this information to help update the campus wide inventory of radioactive materials. It is your responsibility to maintain all active Inventory Forms in a readily accessible location.

When your lab receives radioactive materials it becomes an “active use” laboratory and the requirement for periodic surveying for radioactive contamination applies. The survey frequency is determined by the RSC when approving a Radioactive Materials Users Permit application. The frequency is based on the amount of the material that the permit allows, the process employed and the radiotoxicity of the material.

It is the user’s responsibility to perform and document the required surveys at the minimum frequency. These surveys are to be maintained in the lab and will be inspected at least quarterly by the Radiation Safety Staff.

AMBIENT RADIATION LEVEL SURVEYS

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

- Dose-rate surveys, at a minimum, should be performed in locations where workers are exposed to radiation levels that might result in radiation doses in excess of 10% of the occupational dose limits or where an individual is working in a dose rate of 2.5 mrem/hr or more.
- He-P 4020.13 requires that the total effective dose equivalent to an individual member of the public from the licensed operation does not

exceed 0.1 rem in a year and the dose in any unrestricted area from external sources does not exceed 2 mrem in any one hour.

CONTAMINATION SURVEYS

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

Contamination surveys should be performed:

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

CONTAMINATION SURVEY FREQUENCY

Personnel should survey for contamination in locations where individuals are working with an unsealed form of radioactive material. These surveys should be done at a frequency appropriate to the types and quantities of radioactive materials in use. This frequency is listed on the Radioactive Material Users Permit. If the activity used is greater than or equal to the smallest annual limit on intake (ALI) (for either inhalation or ingestion) as identified in He-P 4090.1, then documented surveys should be performed at least daily in accordance with He-P 4021 and 4022.

The following table contains suggested contamination survey frequencies based on ALIs. The suggested frequency of surveys is based upon the amount of licensed material “in use” at any one time at any particular

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location. If licensed material has not been used for a period of time greater than the required survey frequency, then it is considered to be “not in use.”

Contamination Survey Frequency			
	< 0.1 ALI	> 0.1 ALI < 1.0	> 1.0 ALI
In Use	Monthly	Weekly	Daily
Not in Use	Every 6 Months		

The contamination survey frequency schedule that you need to follow shall be listed on the Radioactive Materials Users Permit.

CONTAMINATION IN UNRESTRICTED AREAS

Contamination found in unrestricted areas should be immediately decontaminated to background levels. When it is not possible to get to background levels, UNH will ensure that the amounts do not exceed the contamination levels listed in the following table.

Acceptable Surface Contamination Levels for Equipment			
Nuclide ^a	Average ^{b,c}	Maximum ^{b,d}	Removable ^{b,e}
¹²⁵ I	1.7Bq/100cm ² (100dpm/100cm ²)	5.0Bq/100cm ² (300dpm/100cm ²)	0.3Bq/100cm ² (20dpm/100cm ²)
¹³¹ I	16.7Bq/100cm ² (1,000dpm/100cm ²)	50.0Bq/100cm ² (3,000dpm/100cm ²)	3.3Bq/100cm ² (200dpm/100cm ²)
Beta-gamma emitters except those noted above	83.3Bq/100cm ² (5,000dpm/100cm ²)	250Bq/100cm ² (15,000dpm/100cm ²)	16.7Bq/100cm ² (1,000dpm/100cm ²)

Note: 1 Bq = 1 Disintegration per second

- a Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.
- b As used in this table, dpm (disintegration per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

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- c Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.
- d The maximum contamination level applies to an area of not more than 100 cm².
- e The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

When equipment or facilities that are potentially contaminated are to be released for unrestricted use, the above table provides the maximum acceptable residual levels for equipment, and the table below provides action limits and ALARA goals for removable contamination control. To the extent practicable, it is appropriate to decontaminate to below these levels. Surface contamination surveys should be conducted for both removable and fixed contamination before these facilities or equipment are released from restricted to unrestricted use, to ensure that they meet these limits.

A standardized method for smear testing of a relatively uniform area should be used to aid in comparing contamination at different times and places. A smear taken from an area of about 100 cm² is acceptable to indicate levels of removable contamination.

Action and ALARA Limits for Removable Surface Contamination Levels		
Nuclide	Action Level	ALARA Goal
¹²⁵ I	0.3Bq/100cm ² (20dpm/100cm ²)	0.3Bq/100cm ² (20dpm/100cm ²)
¹³¹ I	1.7Bq/100cm ² (100dpm/100cm ²)	3.3Bq/100cm ² (200dpm/100cm ²)
Beta-gamma emitters except those noted above	1.7Bq/100cm ² (100dpm/100cm ²)	3.67Bq/100cm ² (220dpm/100cm ²)

8. **Administrative Issues**

During the course of using radioactive materials, some administrative issues are certain to arise. Many of these issues are addressed in this guide or at the UNH OEHS website (see inset). If the answer to your situation is not located in one of these two resources, please contact the Radiation Safety Officer.

OEHS Web Address

www.unh.edu/ehs

8.1 Forms

In general all radiation safety related forms are available on the OEHS website. Links to the most commonly used forms are included in the Resources section of this guide.

8.2 Training Registration

Registration for classes can be accomplished by either an email or telephone call to the Radiation Safety Officer.

8.3 Dosimetry

You will be issued the required dosimetry at specific intervals (e.g. every two months). It is your responsibility to return the last period dosimeter(s) in a timely fashion and begin using the current dosimeter(s) upon receipt. Should you misplace or damage a dosimeter, contact the Radiation Safety Officer immediately to schedule a replacement dosimeter.

Should you require additional dosimeters for visitors, contractors or other uses, contact the Radiation Safety Officer. Please allow at least four weeks for any new request to be processed.

8.4 New Employees

All new employees who are expected to use radioactive materials as a function of their job must complete a new employee questionnaire for the Radiation Safety Officer. This questionnaire can be obtained from the Radiation Safety Officer and is distributed at the in-person initial Radiation Worker training. The link to this form is located in the Resources Section of the guide.

8.5 Exposure Review Request

All requests to review exposure histories must be made in writing and submitted to the Radiation Safety Officer.

8.6 Bioassay Sampling

Bioassay sampling will be conducted in accordance with the schedule determined in the Radioactive Material Users Permit. Thyroid scans and/or urine samples will be collected at pre-determined intervals and must be scheduled by contacting the Radiation Safety Officer.

8.7 Job Hazards Assessment

Job Hazards Assessments (JHA) may be requested by any employee who uses hazardous or radioactive materials during the course of their work. JHAs for radioactive materials may only be scheduled with the Radiation Safety Officer. All other JHA requests should be directed to OEHS.

9. DECLARED PREGNANT WORKERS

UNH maintains a Declared Pregnant Worker (DPW) program as a subunit of its Radiation Protection Program. The DPW program allows all pregnant Radiation Workers additional protection from ionizing radiation exposure.

Declaration of pregnancy is optional and is at the sole discretion of the Radiation Worker. Declared Pregnant Women must issue their declaration in writing to the RSO and include the estimated date of conception. A sample declaration is found on the OEHS website. Upon declaration, the worker's dose limitations will be 0.5 REM to the embryo/fetus and:

- 1) All declared pregnant workers (DPW) will receive general information relative to radiation and its potential effect on the fetus.
- 2) DPW will be given specific information and instruction regarding their specific work responsibilities and corresponding radiation safety issues.
- 3) The RSO, or designee, will schedule an appointment with all DPW to discuss the information in #1 above, and to determine an appropriate bioassay schedule.

10. RADIOACTIVE WASTE & WASTE MINIMIZATION

All radioactive wastes generated as a result of research activities will be managed by the Radiation Safety Officer. General guidelines are included herein and specific requirements will be listed in each Radioactive Material Users Permit.

All radioactivity labels must be defaced or removed from containers and packages prior to disposal in ordinary (non-radioactive) waste.

Each waste container to be picked up by OEHS must be labeled to identify the radionuclide, activity, date quantified, Authorized User, waste type, and exterior survey results.

Waste collection requests should be directed to the Hazardous Materials Shipping Specialist at 862-5038. Waste collection requests will be processed within ten business days of receipt. The Authorized User or a Radiation Worker must be present during the waste pickup.

The types and quantities of radioactive waste that will be generated by a research protocol should be estimated during the Radioactive Material Users Permit planning phase. Assistance is available from the Radiation Safety Officer regarding the types of collection containers and shielding that may be required.

The goal of the radioactive waste minimization program is to reduce or eliminate radioactive waste as much as feasibly possible to minimize concerns to public health and the environment as well as providing a significant cost savings for the University. Waste minimization addresses process changes that can be made to accomplish this goal including oversight and review, investigating possible alternative methods of use and disposal, waste minimization training, and source and volume reduction.

Waste Minimization techniques are listed below:

- Lab personnel are trained in waste minimization practices annually.
- Order only the amount of radioactive material necessary for the experimental protocol.
- Minimize waste by disposing of only material that is contaminated. If only a portion of a lay down is contaminated, only dispose of that portion as radioactive waste.
- Whenever possible, clean and reuse items instead of disposing in radioactive waste containers.

- Empty shipping containers (excluding stock vials) and packaging material surveyed and disposed via normal trash.
- Segregate known contaminated items from uncontaminated items.
- Where appropriate, use non-porous lipped trays that can be decontaminated if necessary, rather than paper protective coverings.

10.1 Dry Active Waste (DAW)

Dry Active Waste (DAW) is characterized by common lab materials such as pipette tips, bench coat, latex gloves, etc. contaminated with radioactive material. DAW should be segregated by radionuclide. General acceptance criteria for dry active waste include:

- No free standing liquid.
- No uncontained sharps (e.g. needles, razor blades, broken glass).
- No hazardous wastes (e.g. lead, thorium nitrate, etc.).
- No active biological material (e.g. animal wastes, blood, etc.).
- No sealed sources.

10.2 Aqueous Liquids

Aqueous liquids containing radioactivity must be collected in sturdy containers with secondary containment. Aqueous liquids containing I-125, P-32, and other radionuclides with $T_{1/2} < 90$ days are collected by OEHS for decay in storage. Liquid waste to be picked-up by OEHS must be labeled with a Radioactive Waste Tag. ***Other aqueous liquids may be disposed via sanitary sewer release upon approval by the Radiation Safety Officer.*** In general, aqueous liquids must conform to the following specifications prior to disposal:

- pH 5-9.
- No solids.
- No hazardous wastes.
- No biological wastes.
- Approval from RSO for drain disposal.

10.3 Liquid Scintillation Vials

Liquid scintillation vials (LSV) should be segregated by radionuclide

and by cocktail type (e.g. hazardous v. non-hazardous). LSVs shall be stored in vial flats for pick-up by OEHS and labeled with “Caution Radioactive Material” labels. LSV waste should not include paper, gloves, cocktail containers, or anything other than liquid scintillation vials. Vial caps should be tightened prior to disposal to discourage leakage.

10.4 Animal Carcasses and Bedding

Animal carcasses and bedding contaminated with radioactive materials should be kept separate from other wastes. These materials require special packaging and processing. Waste should be segregated by radionuclide. Carcasses should be kept frozen until collection for disposal. Carcasses and bedding should be free of any surgical implement (syringe, scalpel) or apparatus.

10.5 Mixed Waste

Mixed waste is any radioactive waste that is also contaminated with a hazardous or biological material. Though liquid scintillation and animal wastes meet this definition there are existing treatment strategies available for these waste streams and they are categorized as specific wastes. Mixed waste is often very expensive to dispose and in some cases no viable disposal option exists. For these reasons, mixed waste is not allowed to be generated at UNH.

10.6 Sealed Sources

Sealed sources are concentrated amounts of radioactive material on a small surface area (e.g. radium beads, disc sources) used for instrument calibration, sample dosing or quality assurance “check sourcing.” Due to the concentrated amount of radioactive material ($> 1\mu\text{Ci/cc}$) often present in sealed sources, these materials must be specially packaged and processed. The Radiation Safety Officer maintains a campus-wide listing of sealed sources and will inventory these sources bi-annually. Contact the Radiation Safety Officer if you have a sealed source that you wish to dispose.

11. RADIATION SAFETY PROTECTION PRINCIPLES

Radiation protection principles, as well as other important topics relating to radiation, will be covered during initial and recurrent training. The following information is included as a reference resource. Additional information is available at the OEHS website or by contacting the Radiation Safety Officer.

Radiation exposure of workers can come from two types of sources, **external** and **internal**. **External exposure** results from radiation sources outside of the body emitting radiations of sufficient energy to penetrate the body and potentially damage cells and tissues deep in the body. External exposure is thus type and energy dependent. As a general rule, X-rays, γ -rays and neutrons are external hazards as are β -particles emitted with energies exceeding 200 keV ($E > 200$ keV). Beta particles with $E < 200$ keV (^3H , ^{14}C , ^{35}S) do not go far in air and do not have enough energy to penetrate the skin. **Internal exposure** comes from radiation sources taken inside the body (e.g., inhalation, ingestion, injection, or absorption through the skin) which then irradiate surrounding cells and tissues. Both types of exposure potentially carry risk. Thus, when using radiation or radioactive materials, workers must understand and implement basic radiation safety principles to protect themselves and others from the radiation emitted by the radioactive materials and from radioactive contamination in the work place. These basic radiation protection principles are **time, distance, shielding, and housekeeping**.

11.1 Time

The linear, no-threshold dose-response model assumes no cellular repair and that radiation damage is cumulative. Therefore, the length of time that is spent near a source of radiation determines the radiation exposure received and the consequent risk. Most work situations require workers to handle radioactive materials for short periods. For new procedures, a worker can reduce this "timely" radiation exposure by first practicing the new procedures with simulated radiation sources. Once proficient, the worker can work more rapidly with real sources and thus receive a lower exposure than if they had gained that proficiency with real radiation.

11.2 Distance

Like light, radiation is greatly affected by distance. Up close, a light appears bright, but as one moves away, the light grows dim. Similarly, the exposure rate from a radiation source decreases with distance.

Gamma ray exposure from a point source (i.e., distance greater than 7-times the dimension of the source) of radiation follows the **Inverse Square Law**. This specifies that if you double the distance from a point source of radiation, the radiation intensity will decrease by a factor of 4. For example, if the unshielded radiation intensity at 50 cm from a 10 mCi vial of ^{22}Na is 50 mR/hr, then at 100 cm from the source, the radiation intensity will decrease to 12.5 mR/hr, and at 200 cm (i.e., twice 100 cm, 4 times 50 cm) the intensity will only be 3.1 mR/hr.

Increasing the distance from a source of radiation is often the most effective way of decreasing exposure. Do not stand or sit near unshielded radiation sources unless actually working with the radiation.

When it is not necessary for you to handle penetrating sources of radioactive materials, stand at least 6 feet from the source. If you must work with high activity sources (greater than 1 millicurie of ^{32}P , ^{51}Cr , ^{111}In or ^{125}I), work at arms length, use tongs, or long-handled tools to increase the distance to your hands and your whole body.

11.3 Shielding

External radiation deposits energy and produces ionizations in the matter that it passes through. Anything placed between the source of radiation and the worker will absorb some of the radiation energy and reduce exposure. A shield is a material of some thickness that will stop or effectively reduce radiation. However, recall that different radionuclides emit different types and energies of radiation; these radiations require different types and densities of shielding material to absorb the radiation.

11.3.1 Alpha Particles

Because of their large size and charge, alpha particles can be stopped by very thin absorbing materials. A few sheets of paper or thin aluminum foil will absorb alphas from any source. The most energetic alpha will travel only about 5 cm in air. The dead layer of the skin will absorb all alpha particles with no harmful effect. Therefore, alpha radiation is not considered an external hazard.

11.3.2 Beta Particles

Beta particles interact in ways similar to alpha particles. Compared to an alpha particle, a beta particle has a small mass and, for the same energy, will have a greater velocity (i.e., $E = 1/2mv^2$). Thus, a beta particle is less densely ionizing and will penetrate farther into an absorber than an alpha particle. In order to penetrate the dead layer of the skin, a beta

particle must have an energy greater than 70 keV (0.07 MeV). For this reason, most beta radiation is considered only a slight external hazard and is mainly a skin exposure hazard.

Shielding of beta particles is accomplished by using light materials (e.g., plastic, lucite, plexi-glass, etc.). Just a few millimeters of plastic will stop even the high energy beta particles from ^{32}P . Dense materials (e.g., lead) are not suitable for stopping high energy (> 500 keV) beta particles because, as the beta particles slow down in dense shields, they produce a type of X-ray called **Bremstrahlung** (i.e., braking radiation). Thus, lead shielding causes a particle radiation of short penetration to emit electromagnetic radiation of high penetration. High-energy beta particles stopping in light materials do not produce as much (e.g., a factor of 10 less) Bremsstrahlung. Therefore, lucite is the preferred shielding material for these sources. Shielding is not needed for low energy (< 200 keV) beta particles.

11.3.3 Gamma Rays

Gamma rays do not lose energy continuously, as do α or β particles, when passing through matter. Thus, gamma ray photons are much more penetrating than α or β particles. Until the photon interacts, no energy is given up to the matter. When they do interact, the result is the release of energetic orbital electrons. These interactions are proportional to the number of orbital electrons. Shielding of x or gamma rays is best accomplished by using dense materials (e.g., lead, leaded acrylic, etc.) or a great thickness of less dense material (e.g., steel, concrete). Lead is preferred because of its great density. Gamma rays and X-rays with energies less than 2.0 MeV will be reduced by at least a factor of 10 by a 2-inch thickness of lead.

11.3.4 Positrons and Mixed Beta-Gamma Emitters

Shielding radionuclides that emit both high-energy beta and gamma radiations (e.g. ^{22}Na , ^{131}I , etc.) is done with graded shielding. Closest to the source, light material is used to stop the beta particles. Next to the light material, dense material is used to stop the gamma rays and any Bremsstrahlung X-rays produced in the light material. For most practical applications involving beta/gamma emitters, using enough lead to reduce the gamma exposure rate by a factor of 10 is enough to stop the beta and Bremsstrahlung X-rays produced.

11.4 Housekeeping

Many research procedures at the University of New Hampshire use unsealed sources of radiation. The deposition of unsealed radioactive material in the body can result in prolonged internal radiation exposure. Radioactive materials can enter the body through inhalation, ingestion, injection (or puncture), or skin absorption. Once inside the body, the potential for cellular damage by particulate (especially alpha and low-energy beta particles) radiation is often greater than if the same radiation source were outside the body.

Thus, it is essential that radiation workers utilize the basic principles of time, distance, and shielding in combination with good housekeeping practices to keep radionuclides from getting inside the body. When working with radioactive materials, adhering to the precautions listed below will ensure that radiation exposure (and consequent risk) will be As Low As Reasonably Achievable.

- Do not eat, drink, smoke, or do other hand-mouth operations (e.g., licking stamps or labels, applying makeup, etc.) in any room or lab that has been posted “Caution - Radioactive Materials.”
- Do not mouth pipette, not even water. Bad practices, once started, may become habitual with the consequent risk of ingestion of radioactive materials or other toxic substance.
- Do not store food or drink containers in the same location as radioactive materials. This particularly applies to refrigerators containing (or labeled as containing) radioactive materials; these refrigerators are off limits for lunch bags, milk cartons, and other food or drink containers.
- Do not bring personal belongings into radioactive work areas of the lab. Avoid wearing rings, watches, and similar items during work. Always wear appropriate clothing (e.g. shirts, shoes) in the laboratory. Open sandals are prohibited; shorts and skirts are not recommended.
- Use double gloves when working with radioactive materials if there is an abrasion of the skin below the wrist.
- Wear protective clothing (e.g., disposable gloves, lab coat, safety glasses) when handling radioactive materials; these shield skin and clothing from contamination. Leave these items in the lab when you leave.

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- If issued radiation dosimeters, wear it/them when working with radiation sources. Store your dosimeter(s) in an approved low background area.
- Radiation workers should be thoroughly familiar with the properties of the radionuclides they are using. If you are uncertain about the safety of a procedure contact the Authorized User or the Radiation Safety Officer.
- Employ the four basic safety principles of time, distance, shielding, and housekeeping, whenever you work with radioactive materials.
- Assume containers labeled “Caution - Radioactive Material” are also contaminated. Wear disposable gloves, lab coats and safety glasses when handling all such containers.
- Perform a "dry run" without radioactive materials to learn new procedures.
- Work must be done in a fume hood if gas, vapor, dust or aerosols can occur during the procedure.
- Do radiation work on an impervious spill containment tray capable of containing the entire volume of a liquid radioactive material in case it is spilled. Cover the work area with plastic-backed absorbent material.
- Wash hands thoroughly immediately after working with radioactive materials,.
- Monitor hands and clothing for evidence of radioactive contamination during and after work; especially before leaving the lab.
- Monitor work area and adjacent floor for contamination after working with radioactive material. Decontaminate, if necessary, and re-monitor.
- If you are contaminated with radioactivity, or suspect contamination, wash the contaminated area with warm soap and water and notify the Radiation Safety Officer immediately.
- Monitor the rooms where radioactivity is used or stored, and pay special attention to all areas which may come in contact with

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potentially contaminated hands, e.g., phones, door knobs, refrigerator/freezer handles.

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12. RADIONUCLIDES USED AT UNH

UNH is licensed to possess and use a number of radioisotopes. In reality however the University employs only a handful of radioisotopes on a consistent basis. These isotopes are represented in the following table:

Isotope	Symbol	Half-life	Radiation	Energy (MeV)
Hydrogen-3 (Tritium)	^3H	12.3 years	β^-	0.0186
Carbon-14	^{14}C	5730 years	β^-	0.157
Phosphorus-32	^{32}P	14.28 days	β^-	1.709
Phosphorus-33	^{33}P	25.3 days	β^-	0.249
Sulfur-35	^{35}S	87.2 days	β^-	0.167
Calcium-45	^{45}Ca	162.7 days	β^-	0.258
Chromium-51	^{51}Cr	27.7 days	γ	0.320
Iodine-125	^{125}I	60.1 days	γ	0.035
Iodine-131	^{131}I	8.04 days	β^- γ	0.606 0.364
Cesium-137	^{137}Cs	30.17 years	β^- γ	0.514 0.662
Rubidium-86	^{86}Rb	18.63 days	β^- γ	1.744 0.0519
Indium-111	^{111}In	2.83 days	β^- γ	0.245 0.171

Additional information on these, and other, radioactive materials is available on the OEHS website.

13. FREQUENTLY ASKED QUESTIONS

Even though the Radiation Safety Officer has tried to present the information in this Guide in a very simple and brief form, common questions do still arise. In anticipation of this, the following “top ten” list of frequently asked questions are answered. Should you not find your question (or your answer) in this list, kindly contact the Radiation Safety Officer.

1) How do I get started using radioactive materials?

You need to do the following:

Complete a Radioactive Materials Users Permit application;
Complete the required administrative processing;
Complete radiation safety training;
Receive approval for the Permit application;
Receive dosimetry (or bioassay schedule);
Procure any required radiation safety equipment and supplies;
Submit completed Purchase Request to Radiation Safety Officer.

Your radioactive material will arrive in a few days.

2) I lost my dosimeter, what do I do?

Contact the Radiation Safety Officer (862-3607) as soon as you recognize that your dosimeter is missing. Complete a dose assessment interview with the RSO and receive a replacement (spare) dosimeter. When the next period arrives you will receive your new dosimeter.

3) Why do I *have* to attend radiation safety training?

UNH has committed to full and complete compliance with all State of New Hampshire laws and regulations governing the safe use of radioactive materials. In keeping with this commitment and these regulations, all individuals who work with radioactive materials must complete initial and annual refresher training. This once a year training gives the Radiation Safety Officer an opportunity to apprise you of changes in the regulations or University procedures.

4) Whose responsibility is it to survey my lab?

All labs that are authorized for radioactive material use will be assigned a survey schedule as a part of the Radioactive Materials Users Permit. This schedule will detail the minimum frequency for lab radiation safety surveys. It is each individual lab's responsibility to assign, conduct and document these surveys.

5) Who do I call for a waste pick-up?

Contact the Hazardous Materials Shipping Specialist, OEHS, at 862-5038. Please allow ten business days for your request to be filled. For hazardous or biological waste pick-ups call OEHS at 862-4041.

6) What are the proper units for recording contamination surveys?

The proper units for recording contamination surveys are units of activity per one hundred centimeters squared (i.e. dpm/100cm² and not cpm/100cm²).

7) How can I review my exposure history?

You can request in writing a review of your occupational radiation exposure history. The request should be sent to the Radiation Safety Officer. The RSO will contact you and set a mutually acceptable time to review your occupational radiation exposure history.

8) I have this friend who is pregnant and uses radioactive materials, what should I tell her to do?

Tell your friend about the Declared Pregnant Worker program at UNH (see Section 9). If she's interested in more information have her contact the Radiation Safety Officer (862-3607). If she's ready to enroll in the Declared Pregnant Worker program have her submit a declaration form (found on the OEHS website) to the Radiation Safety Officer.

9) What do I do with this completed Radioactive Materials Inventory Form?

Radioactive Materials Inventory forms are required for all source vials. Once a source vial is empty, or disposed as waste, the

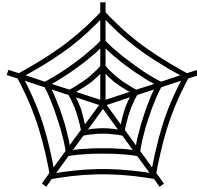
completed tracking form should be retained in your records for review.

10) Where can I get copies of Radiation Safety Forms?

Copies of commonly used Radiation Safety forms are available electronically from the OEHS website.

14. RESOURCES

There are a number of valuable resources available to you, including the following web-based resources:



web-based resources

<http://www.unh.edu/ehs/radsafety/>- most commonly used forms

www.unh.edu/ehs

www.nrc.gov

www.dot.gov

<http://www.dhhs.state.nh.us/DHHS/RADHEALTH/default.htm>