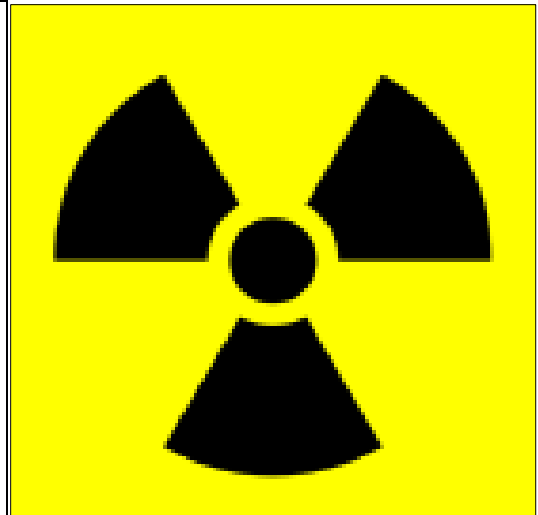


THE SAFE USE OF RADIOACTIVE MATERIALS

University of Delaware
Department of Environmental Health and Safety
www.udel.edu/ehs
302-831-8475 work hours/ 831-2222 after hours

The most current version of this manual can be found
at the DEHS web site- www.udel.edu/ehs



Revision Date 7/27/2018

Contents

	Page
Administration of the UD Radiation Safety Program	3
Approval to Supervise Radioactive Material Use	4
Authorization to Handle Radioactive Material	5
Ordering of Radioactive Material	6
Radioactive Material Package Surveys	7
Transfers of Radioactive Materials between Laboratories	8
Use of GM Survey Meters	9
Conducting a Wipe Test	10
Safe Handling of Radioactive Materials: Time/Distance/Shielding	11
Safe Handling of Radioactive Materials: Contamination Control	12
Post-Experiment Contamination Surveys	13
Recordkeeping Requirements	14
Disposal of Radioactive Materials	15
Use of Radiation Dosimeters (Badges)	16
Monitoring for Internal Contamination	17
Security of Radioactive Materials	18
Sealed Radioactive Source Requirements	19
Radioactive Material Spills and other Incidents	20-22

Administration of the UD Radiation Safety Program

The University of Delaware (UD) holds a Nuclear Regulatory Commission (NRC) license to conduct certain activities utilizing radioactive materials. The license number is 07-01579-19. The University must renew the license every ten years. Radioactive material workers may request to see a copy of the license by contacting the Radiation Safety Officer at 302-831-8475.

The University also is registered with the State of Delaware Office of Radiation Control as a facility authorized to use radioactive material in Delaware.

The administration representative for the NRC license is the Vice President for Research, Scholarship and Innovation. This person receives all official communications from the NRC and also appoints the Radiation Safety Officer and the members of the UD Radiation Safety Committee.

The type of NRC license that the University holds is called a specific license of broad scope. This means that the University is empowered to approve uses of radioactive materials internally. This is one role of the Radiation Safety Committee (RSC). The RSC is composed of 1) members with technical knowledge in the safe use of radioactive materials, 2) the Radiation Safety Officer, and 3) members that represent the administration. Faculty and others that wish to supervise a project involving the use of radioactive materials must submit details of the project to the RSC for review. The RSC also determines what procedures must be followed by UD staff to ensure compliance with the requirements of the NRC license.

The Radiation Safety Officer (RSO) is the person who manages the radiation safety program as defined in the NRC license and as directed by the RSC. He/she must be specifically named on the NRC and must have adequate credentials to protect radiation workers and enforce compliance with safety requirements. The RSO is empowered with the authority to require the immediate termination of any unsafe activity. The Radiation Safety Technician assists the RSO with management of the program.

The NRC conducts on-site inspections of UD's use of radioactive materials at approximately three year intervals. One or two inspectors will typically spend two to three days on campus reviewing radiation safety procedures, examining required records, visiting radiation use laboratories, and interviewing radioactive material users. Citations and fines can be issued for failure to comply with NRC requirements. Radioactive material workers may request to see NRC inspection reports by contacting the RSO at 302-831-8475.

The presence of a positive safety culture is an important component of the UD radiation safety program. UD leadership has committed resources and other support to the radiation safety program. Radioactive material users are encouraged to share ideas for improvement. Radiation safety staff work with radioactive material users in a collegial manner when deficiencies are identified. Additional information about ways UD promotes a positive safety culture can be found at the UD Environmental Health and Safety website under *Radioactive Materials Program* (www.udel.edu/ehs).

Official Use Only - Security-Related Information		
U.S. NUCLEAR REGULATORY COMMISSION MATERIALS LICENSE		
<small>Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 36, 39, 40, and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 163 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.</small>		
Licensee 1. University of Delaware Department of Occupational Health and Safety 2. General Services Building, Room 132 222 South Chapel Street Newark, Delaware 19716	In accordance with the letter dated September 6, 2012, 3. License number 07-01579-19 is amended in its entirety to read as follows: 4. Expiration date November 30, 2015 5. Docket No: 030-10925 Reference No.	6. Byproduct, source, and/or special nuclear material A. Any byproduct material with atomic numbers 1 through 83 and half-life less than or equal to 120 days B. Any byproduct material with atomic numbers 1 through 98 and half-life greater than 120 days C. Any byproduct material with atomic numbers 1 through 83 D. Cesium 137 E. Polonium 210
7. Chemical and/or physical form A. Any B. Any C. Sealed and Plated Sources D. Sealed Sources (Amersham Type X B) E. Sealed or Plated Sources	8. Maximum amount that licensee may possess at any one time under this license A. 250 millicuries per radionuclide and 20 curies total (and see Condition 10.C.) B. See Conditions 10.C. and 13. C. 50 millicuries per source and 1 curie total D. 120 millicuries E. 100 microcuries	
9. Authorized use: A. and B. Research and development as defined in 10 CFR 30.4; animal studies; teaching and training of students. C. and E. Research and development as defined in 10 CFR 30.4; teaching and training of students.		
Official Use Only - Security-Related Information		

Approval to Supervise Radioactive Material Use

Faculty members and others that wish to supervise a project involving the use of radioactive materials must first obtain authorization from the Radiation Safety Committee. Below are the steps to follow.

- The applicant meets with the Radiation Safety Officer (RSO) to complete an *Application for Radionuclide Utilization* (RSO phone 302-831-8475). The application form can be found at the UD Environmental Health and Safety (EHS) website in the *Forms* section (www.udel.edu/ehs). The application requires that the applicant identifies all those that will work in the room(s) where radioactive materials are used or stored, the radioisotope(s) desired, the possession limit and annual ordering limit for each requested radionuclide, the room(s) where radioactive materials will be used or stored, and the type of radiation detecting equipment that will be used. The applicant includes with the application a completed *Statement of Training and Experience* form (also found on the EHS web site) and a written procedure for each requested experiment that involves the use of radioactive material.
- At this meeting, the RSO will provide the applicant with radiation safety training and provide indoctrination in the workings of the UD radiation safety program including the responsibilities of a Radioactive Material Supervisor.
- The applicant provides the RSO with a tour of the proposed radioactive material work and storage areas.
- The RSO reviews the application and attachments for completeness and forwards the documents on to a member of the Radiation Safety Committee (RSC). The RSC member will contact the applicant to schedule a meeting to review the application and may suggest that changes be made in the proposed use of radioactive material.
- Once the RSC member completes the review, he/she informs the RSO that conditional approval should be granted. The RSO will inform the applicant and schedule a time to meet to prepare the laboratory for radioactive material work (i.e. post the room, label radioactive work benches, deliver radioactive waste containers, etc.). Radioactive material experiments may then proceed. The length of time it may take the applicant to get to this point is typically two weeks from the time the applicant provides the RSO with a complete application.
- Final approval of the application is discussed and decided by the entire Radiation Safety Committee at its next quarterly committee meeting. The RSO will inform the applicant of the Committee's decision and, if the decision is favorable, a Radioactive Material Permit is issued.

Radioactive Material Permits are issued for a two year period. The RSO will contact the Permit Supervisor prior to the expiration of the Permit to schedule a meeting to renew the Permit for an additional two years. During the renewal meeting, the RSO will provide the Permit Supervisor with the required radiation safety refresher training.

Should amendments to the Permit be required (e.g. to add additional radioactive material experiments, change radioactive material work locations, increase radioisotope usage limits, etc), the Permit Supervisor submits the amendment request to the RSO who will then assist with the permit amendment process.

All workers that will handle radioactive material under a Permit must first complete radiation safety training (see manual section *Authorization to Handle Radioactive Material*). Also see this section for the training requirements for those that will work in radioactive material laboratories but will not handle radioactive materials.

Authorization to Handle Radioactive Material

Radioactive materials may only be handled by a worker under the authorization of a Radioactive Material Permit held by Radioactive Material Permit Supervisor. See manual section *Approval to Supervise Radioactive Material Use*.

All workers that will handle radioactive materials must first- 1) complete on-line *Radioactive Material Safety Training*, and 2) meet with the Radiation Safety Officer (RSO) for supplemental training. Workers that have attended radioactive material safety training at another university or work location are *not* exempted from completing this training.



Following the RSO initial training, the Permit Supervisor must provide the worker with hands-on instruction in the safe use of radioactive material. This instruction may be provided directly by the Permit Supervisor or by a properly qualified designee of the Permit Supervisor. This instruction typically involves the worker first observing radioactive material experiments being conducted by an experienced radioactive material worker, followed by the worker conducting experiments themselves with an experienced worker providing direct supervision. This training could also include the worker conducting a “dry-run” of the experiment (without radioactive material) under the supervision of an experienced radioactive material worker.

Every worker that will handle radioactive material must complete a *Permit Supervisor Training Certification* form with their Permit Supervisor and submit it to the RSO. This form can be found at the UD Environmental Health and Safety (EHS) website in the *Forms* section (www.udel.edu/ehs). The Permit Supervisor will indicate on the form whether the worker is a “Trainee” or “Authorized User”. Trainees are those workers with no, or limited, radioactive material handling experience who must be directly supervised by an experience worker whenever handling radioactive material. After a period of time (to be determined by the Permit Supervisor), the Permit Supervisor may advance Trainees to Authorized User status by notifying the RSO via campus mail or email.

In some circumstances, the RSO will be required to be present during a worker’s initial set of radioactive material experiments. This requirement would be imposed by the Radiation Safety Committee if, during its review of the experimental protocol, the Committee believes there may be an increased risk of worker radiation exposure or facility contamination. Examples of such protocols are: radioiodination, radioactive material injected into live animals, experiments with starting activities exceeding 25 millicuries, experiments resulting in airborne release of radioactive gas/vapor/aerosol.

Refresher Training-- Every calendar year following the initial training lecture, radioactive material workers must complete radiation safety *refresher* training (which is available on-line or in a lecture format) in order to maintain authorization to use radioactive materials.


Ordering of Radioactive Material

Although lab staff are free to contact suppliers of radiochemicals for information regarding products, their availability, pricing, etc., they **may not** place an order with the radiochemical vendor. Orders may only be placed by the Radiation Safety Officer and other approved Environmental Health & Safety (EHS) staff.

To initiate an order for a radiochemical, a worker must first have the permission of the Permit Supervisor. Once that has been obtained, the worker completes the webform entitled *EHS: Radioactive Material Requisition* found on the UD webforms site (www.udel.edu/webforms). The form requires the worker to enter the name of the radiochemical, amount desired, vendor name, lab contact information, etc. The code for the funding source/grant that will be used to pay for the radiochemical must also be entered. The worker routes the webform to a person within the worker's department who can confirm that the grant code is valid and there are sufficient funds to pay the cost. Once this person "approves" the form, EHS receives a copy.

After obtaining the approval of the Radiation Safety Officer, an EHS staff member places the order. Radioactive material packages are delivered to the EHS office, usually within one or two workdays after ordering. Upon receipt, an EHS staff member conducts a survey of the package exterior for contamination that may have occurred during transit. If the package is found to be uncontaminated, an EHS staff member delivers the radioactive material package to the ordering lab. A *Radioactive Material Receipt, Use, and Contamination Survey Record Form* will be delivered along with the package. This form is used by radioactive material users to log information regarding the use of the radioactive material within the package. The lab must maintain a Radiation Use Log Book for the storage of these forms.

Within three hours of the receipt of a radioactive material package in the lab, a radioactive material user must conduct a contamination survey of the package and its contents. See manual section *Radioactive Material Package Surveys*.



**ENVIRONMENTAL
HEALTH &
SAFETY**

A Safe and Healthful Campus Environment

Radioactive Material Requisition

Questions about this order? Call Environmental Health and Safety at 831-8475 between 8 a.m. and 5 p.m., Monday through Friday. For safety, view the [Radioactive Materials Program](#) guidelines.

Symbol Key: * Required Information

Prepared by:	Fendt, William A		
Preparer's e-mail:	wfendt@udel.edu		
Department:	<input type="text" value="Environmental Health & Safety"/>		
Principal investigator (PI):	* <input type="text" value="(lookup)"/>		
Primary user of ordered material:	<input type="text"/>		(lookup)
Lab phone number:	<input type="text"/>	(use format xxx-xxx-xxxx)	
Lab building and room number:	* <input type="text"/>		
Desired arrival date:	<input type="text"/>	(use format mm/dd/yyyy)	
* For Lewes Orders Only *	<input type="text"/>		
Name of person who will receive package:	<input type="text"/>		(lookup)

Radioactive Material Package Surveys

Within three hours of the receipt of a radioactive material package in the lab, a radioactive material user must conduct a contamination survey of the package and its contents.

The radionuclide user must follow the procedures below when opening radioactive material packages:

- Wear personal protective equipment (lab coat, gloves, eye protection) when opening the package.
- Open the package in an area of the radiation lab marked for radioactive material use.
- Open the package and visually inspect for any sign of damage (e.g. crushed items, broken seals or vials, discoloration of packaging material). Examine the stock vial to confirm that the stock material that was received is the material that was ordered. If you find anything other than expected, stop and notify the RSO.



- Survey the stock vial and packaging material for contamination. For packages containing soft beta emitters (e.g. H-3, C-14, S-35, Ca-45, P-33) wipe tests must be conducted using a liquid scintillation counter (LSC). Packages containing isotopes with beta radiation of higher energy (e.g. P-32, Na-22, Cl-36, Ru-86, I-131) and most gamma emitters (e.g. Cs-137, Cr-51, Fe-59, Co-60) may be surveyed using a thin end-window GM survey meter instead of wipe testing. Packages containing low-energy gamma emitters (e.g. I-125) may be surveyed using a low energy gamma survey meter instead of wipe testing. See manual sections *Conducting a Wipe Test* and *Use of GM Survey Meters*. If contamination is found, stop and notify the RSO.
- Record the findings of the package survey on the *Radioactive Material Receipt, Use, and Contamination Survey Record Form* which was delivered with the package by EHS staff. Add the form to the lab's Radiation Use Log Book.
- If the shipping box and packaging are not contaminated, they may be discarded in the regular trash *after removing or completely defacing all radiation warning labels*.

Transfers of Radioactive Materials between Laboratories

Transfer of radioactive materials from one UD laboratory to another can sometimes be permitted. Transfers between a UD laboratory and a laboratory at another institution (e.g. the university of a collaborator) can also sometimes be arranged. In both cases, it is **imperative** that the person who wishes to make the transfer contacts the UD Radiation Safety Officer (RSO) in advance of the transfer and obtains authorization.



Transfers between UD Laboratories

To initiate a transfer, a worker must first have the permission of his/her Permit Supervisor. A worker in the donor lab is then responsible for contacting the RSO in advance of the transfer. The RSO will check to see if the receiving lab is approved to use the radiochemical and activity to be transferred. If so, the RSO will send the Permit Supervisors of both the donor and the receiving lab written or email authorization that the transfer may proceed.

The RSO will provide the donor lab with instructions on how the physical transfer of the radioactive material must be performed. If the two labs are within the same building, the RSO will often allow a radioactive material user in the donor's lab to walk the radioactive material to the receiving lab in a secondary container. If the two labs are in different, unconnected buildings, an Environmental Health & Safety (EHS) staff member will usually perform the physical transfer.

A worker in the donor lab must make a note of the transfer on the appropriate *Radioactive Material Receipt, Use, and Contamination Survey Record Form* in the lab's Radiation Use Log Book. The receiving lab must initiate a record sheet in their Radiation Use Log Book to document usage and contamination survey results associated with use of the transferred radiochemical.

Transfers from a UD Laboratory to another Institution

To initiate a transfer, a worker must first have the permission of his/her Permit Supervisor. A worker in the donor lab is then responsible for contacting the RSO in advance of the transfer. The RSO will then contact the RSO of the receiving institution to see if the transfer is permitted and also to acquire shipping instructions.

The RSO will package the radiochemical for shipment in accordance with Department of Transportation and other pertinent regulations. The RSO will also arrange for a carrier to conduct the shipment. The RSO will recover the cost of the shipment from the donor lab.

A worker in the donor lab must make a note of the transfer on the appropriate *Radioactive Material Receipt, Use, and Contamination Survey Record Form* in the lab's Radiation Use Log Book.

Transfers from Another Institution to a UD Laboratory

To receive a transfer from another institution, a worker must first have the permission of his/her Permit Supervisor. That worker is then responsible for contacting the UD RSO. The UD RSO will then contact the RSO of the donor institution to see if the RSO is aware of the proposed transfer and to provide shipping instructions to UD.

The package will be shipped to the EHS office and package surveys will be conducted as described in manual sections *Ordering of Radioactive Material* and *Radioactive Material Package Surveys*.

Use of GM Survey Meters

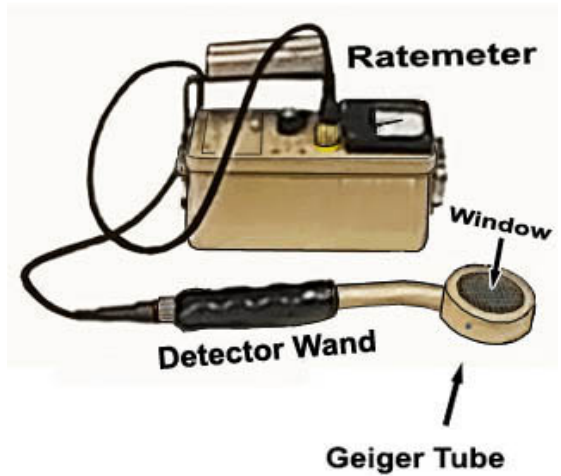
Portable Geiger-Mueller (GM) radiation survey meters can be used to detect the presence of a radiation field surrounding certain radiation sources and estimate the dose rate at the measurement location. Meters can also be used to check for the presence of certain radionuclides on a surface (contamination).

The GM survey meter cannot detect the very weak beta particle emission from H-3 (tritium) and it only poorly detects the weak beta particle emissions of C-14, S-35, and P-33. For this reason, the wipe test method is used instead of a meter to determine if a surface is contaminated. The GM meter, however, is useful for radioisotopes emitting more energetic beta particles (e.g. P-32, Na-22, Cl-36, Ru-86, I-131) and many gamma emitters (e.g. Cs-137, Cr-51, Fe-59, Co-60).

For labs using I-125, a low energy gamma emitter, a meter with a low energy gamma probe is used instead of a GM probe. See picture to right.

Instructions for using a Portable Survey Meter--

1. Depending on the model of meter you have, confirm that the batteries are strong by either turning the ratemeter knob to the "battery check" setting or by pushing the "battery check" button on the ratemeter. If the needle on the face of the ratemeter does not go past the "battery OK" marking, replace the batteries.
2. Turn the ratemeter knob to the lowest setting, usually x0.1 or x1 and confirm that the speaker switch (sometimes labeled "AUD") is ON.
3. At this point, you should hear the meter clicking. The meter is detecting "background" radiation which is always present.
4. To check for the presence of a radiation field, approach the suspected radiation source with the tube "window" pointed towards the source. If the clicking rate increases, a radiation field is present. To obtain a meter reading, multiply the needle reading on the meter face by the factor on the knob setting (e.g. 400 CPM on the x10 scale equals 4000 CPM).
5. To check for the presence of contamination on a surface, clothing, skin, etc., direct the window side of the tube toward the surface and slowly scan at approximately 1 inch per second. Hold the tube close to (but not in direct contact with) the surface. If the clicking rate increases, contamination has been detected.
6. Prior to use, it is good practice to hold the meter tube near a known radiation source to confirm that the meter will respond as expected.



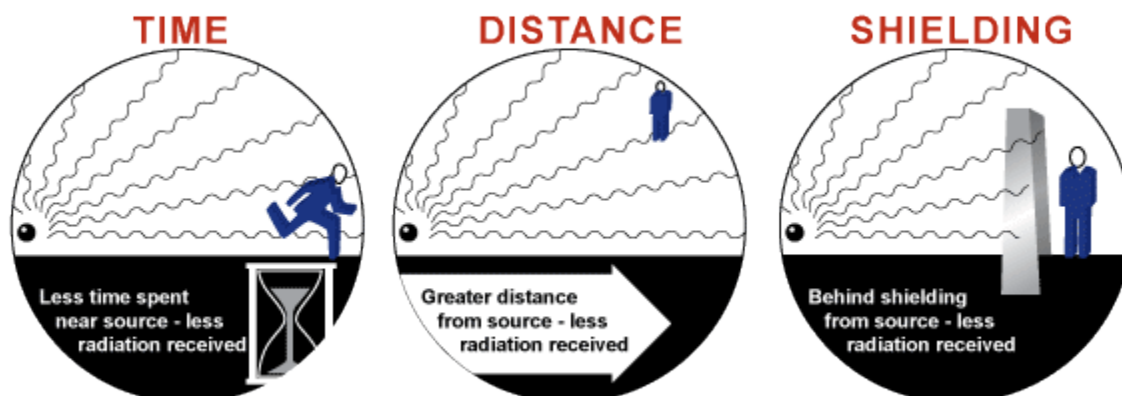
Conducting a Wipe Test

A wipe test is used to detect the presence of radioactive contamination on a surface or item. Using moderate finger pressure, a cotton swab or paper disk is rubbed across the surface/item to be tested. An area of approximately 100 square centimeters is wiped. The wipe is placed in a counting vial and then counted in a radiation instrument which is capable of satisfactorily detecting the radioisotope of interest. If the wipe is found to be radioactive, it is assumed that the surface is contaminated.

Most radioisotopes in use at UD can be detected with good efficiency by a liquid scintillation counter (LSC). This counting method requires the addition of liquid scintillation fluid to the sample prior to counting. Along with the test wipe (or series of test wipes), an unused wipe is also counted. This “blank” or “control” wipe provides a background count rate. Any test wipe which exceeds twice the background count rate is considered to be contaminated and the surface/item corresponding to that wipe needs to be disposed as radioactive waste or else decontaminated. Detailed instruction in the use of the LSC is provided to a new radioactive material user by the Permit Supervisor or his/her experienced designee.



Safe Handling of Radioactive Materials: Time/Distance/Shielding



The radiation dose workers received when working with radioactive materials can be minimized through the use of time, distance, and shielding practices.

TIME

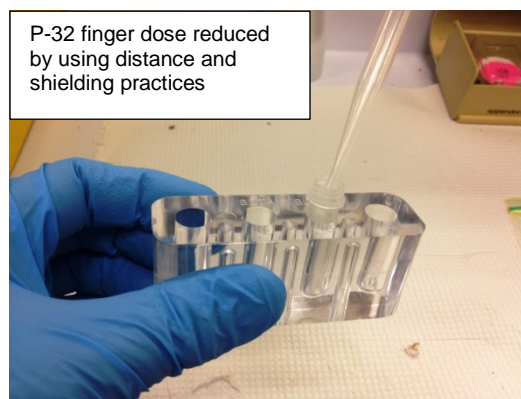
Less time spent in a radiation field results in a lower radiation dose. Practical ways to minimize time are:

- Do dry runs of the experiment (i.e. without radioactive material) to become knowledgeable in the protocol and efficient in your use of time.
- Post a copy of the experimental protocol to ensure the experiment goes smoothly and mistakes are not made. Repeating an experiment because of an error increases your radiation dose.
- When learning a new protocol, work alongside of an experience worker who will coach you and make sure the work is completed in a timely manner.
- After dispensing the needed amount for the experiment from the radioactive stock vial, place the stock vial back in its storage location instead of leaving it on the work bench.

DISTANCE

The strength of the radiation field diminishes with distance from the radiation source. For a point source of radiation, a doubling of the distance results in a four-fold decrease in the dose rate. Practical ways to utilize this concept are:

- Use remote tools to hold or dispense radioactive materials.
- Instead of directly holding microfuge tubes, flasks, vials, etc. with the fingers, use a rack or other device to increase radiation source-to-hand distance.
- Place containers holding radioactive materials (e.g. benchtop waste container) further back on the bench so they are further away from the worker.



SHIELDING

An appropriate shield can block radiation.

- For energetic beta-emitting radionuclides (e.g. P-32), use a plastic shield of 1cm thickness.
- For gamma emitting radionuclides, use lead shielding. The thickness of the shield will depend on which radionuclide is being used; consult with the Radiation Safety Officer.

When working with weak beta-emitting radionuclides (H-3, C-14, S-35, P-33), time/distance/shielding measures are often not necessary. This is due to the short range of the beta particles. Contamination control measures, however, are essential; see manual section *Safe Handling of Radioactive Materials: Contamination Control*.

Safe Handling of Radioactive Materials: Contamination Control

All radionuclides will deliver a radiation dose to the worker if they are in direct contact with the body, either externally or internally. The following practices must be followed whenever handling radioactive materials to minimize the likelihood of contamination of workers and the facilities.

- No eating, drinking, or applying cosmetics is permitted in any room with the radiation warning sign at the entranceway. Storing of food or drink in the room is also not permitted. Never pipet radioactive solutions by mouth.
- A lab coat with long sleeves, disposable gloves, and eye protection must always be worn when handling radioactive materials. No open footwear (e.g. sandals) may be worn.
- Radioactive material work may only be conducted- 1) in rooms that are posted at the entranceway with a radiation warning sign, and 2) on worksurfaces that have been marked with radiation warning tape. Radioactive materials may only be stored in refrigerators, freezers, cabinets, etc. that have been posted with a radioactive material warning sign.
- Radioactive work benches must be covered with benchpaper to contain small spills and protect the worksurface from contamination.
- If lab equipment (e.g. racks, pipetters) has been labeled with radioactive warning tape to indicate it is dedicated for radiation work, this equipment must be retained in the radioactive work area and may not be brought out into the general lab space.
- Change gloves frequently during the radioactive material experiment and wash hands when finished. Remove gloves before handling personal items, such as cell phones, laptops, etc.
- Follow good housekeeping practices in radiation work areas. Clean and organize work area after experiments. Replace soiled benchpaper, dispose of trash, wash items intended for reuse, eliminate clutter.
- Containers placed in storage containing radioactive materials must be labeled with radiation warning tape and also must be marked with the name of the radionuclide, the activity within, and the date (e.g. C-14, 10uCi, 2/23/2018).
- Untrained persons may not be allowed to access radioactive materials. When the lab is vacant, radioactive materials must be secured by either- 1) locking the entranceway door, or 2) locking radioactive material inside a refrigerator or cabinet within the lab using a locking device, such as a padlock. Strangers that enter the lab must be challenged by lab staff.
- Contamination surveys must be conducted after each day of radioactive material use. The results must be documented. Any contamination that is found must be cleaned up immediately. See manual sections *Post-Experiment Contamination Surveys* and *Recordkeeping Requirements*.
- If skin contamination is detected or if there has been a spill, contact the Radiation Safety Officer immediately. See manual section *Radioactive Material Spills and other Incidents*.



Post-Experiment Contamination Surveys

Users of radioactive material must conduct a contamination survey of the radioactive material work area and themselves at the completion of work every day that they handle radioactive materials. All work surfaces and items that may have become contaminated during the course of the day must be surveyed. The floor in the vicinity of the work location must also be surveyed. The user must know the results of the survey and clean any contaminated area/item before leaving the lab for the day.

For these Radionuclides...	... Follow this Survey Technique
H-3, C-14, S-35, P-33, Ca- 45, Fe-55	Wipe Test
P-32	Meter Scan with thin-window GM (Geiger) detector (or Wipe Test)
I-125	Meter Scan with low-energy gamma detector (or Wipe Test)
Others	Check with Radiation Safety Officer

Wipe Test: Areas/items to be tested are wiped using either a dry wipe or cotton swab using moderate finger pressure. An area of approximately 100 square centimeters is wiped. Wipes are analyzed using a liquid scintillation counter. Those wipes with a count exceeding twice the background count are considered contaminated and the corresponding area must be cleaned and re-surveyed. For a more detailed discussion, see manual section *Conducting a Wipe Test*.

Meter Scan: Areas/items to be tested are slowly scanned with the meter by holding the meter probe at a distance of approximately 1 cm or closer to the tested area/item. Those areas with a count rate exceeding twice that of background are considered contaminated and must be cleaned and re-surveyed. Prior to using a survey meter to survey for contamination, (1) use the “battery check” feature of the meter to ensure battery strength is satisfactory and (2) hold the probe near a known source of radiation to confirm that the meter will respond when exposed to radiation. For a more detailed discussion, see manual section *Use of GM Survey Meters*.

Cleaning of contaminated surfaces is not usually difficult. Use of a lab cleaning solution and paper towels is usually all that is required. The towels are disposed in the radioactive waste container. The RSO should be contacted if cleaning is not successful.

At the conclusion of the contamination survey, lab staff must document the results of the survey in the Radiation Use Log Book.

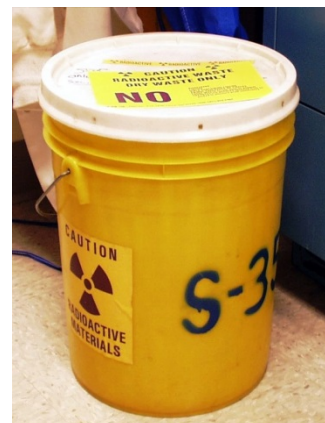


The Radiation Safety Officer must be immediately notified in the following cases: contamination found in public areas, contamination is wide-spread throughout the lab, unusually high levels of contamination are found, contamination found on the skin.

Disposal of Radioactive Materials

Radioactive materials, items contaminated with radioactive materials, and items labeled as radioactive may not be placed in the standard trash receptacle. Radioactive liquids may not be poured down the sink drain. Environmental Health & Safety (EHS) provides radioactive waste containers for collection of such materials.

Radioactive Solid Items: Items such as gloves, empty tubes, benchpaper, pipette tips, etc. are placed into a metal or plastic pail provided by EHS. Pails are marked with the name of the radionuclide that may be deposited in the pail. Labs are issued a separate solid waste pail for each radionuclide in use. It is important to correctly segregate solid waste by radionuclide because the method EHS uses to ultimately dispose of solid waste is determined by the radionuclide. Radioactive sharps (razor blades, needles, scalpels, etc.) must first be placed in a rigid container such as a plastic bottle or heavy cardboard box before placing into the solid waste pail.



Radioactive Liquids: Containers holding radioactive liquids are decanted into a thick-walled plastic carboy (jug) issued by EHS. Carboys are marked with the name of the radionuclide that may be placed inside it. Labs are issued a separate liquid carboy for each radionuclide in use. All radioactive liquid carboys must be stored inside a secondary container in case of leakage.

Radioactive Liquids that contain a Chemical or Biological Hazard: This type of waste is called a “mixed waste” and it may not be added to the standard radioactive liquid carboy. Instead, this waste is decanted into a separate carboy that is labeled with the name of the hazardous chemical (or biohazard) as well as the name of the radionuclide. Disposal of mixed waste is often costly and difficult so generation of mixed waste should be minimized or avoided (if possible). Workers should contact the RSO for guidance if they are uncertain if they are generating a mixed waste.

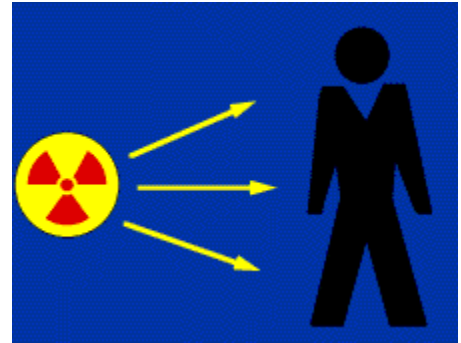
Liquid scintillation vials: The contents of a liquid scintillation vial must not be decanted into a radioactive liquid carboy like other liquids. Instead, the entire vial containing the contents (with the cap still ON) is placed into plastic or metal pails provided by EHS. The pails are marked for “LS Vials Only” and also with the name of the radionuclide that may be placed inside it.

To arrange a collection of radioactive waste, the worker completes the webform entitled *EHS: Radioactive Waste Pick-up Form* found on the UD webforms site (www.udel.edu/webforms). The worker also completes the waste tag attached to the waste container. EHS staff will remove the waste within one week of the request.



Use of Radiation Dosimeters (Badges)

Dosimeters are devices that measure a worker's dose from radiation sources external to the body. Radiation monitoring with dosimeters is conducted when a worker may receive a measurable radiation dose from the work that they perform. Workers using only radionuclides that emit low energy beta particles are not monitored with dosimeters because these beta particles have a very short range and, therefore, cannot reach the dosimeter to be detected. Other workers that use radionuclides that are more energetic are issued dosimeters and must wear them whenever conducting radioactive material work.



Low energy beta emitters	H-3, C-14, S-35, P-33	No dosimeters issued
High energy beta emitters	P-32	Dosimeters issued
Gamma emitters	I-125, Cs-137	Dosimeters may be issued depending on activities handled

During a worker's initial radiation safety training, the Radiation Safety Officer (RSO) will determine whether a worker should be issued dosimeters. If there is a need, dosimeters are delivered to the worker's lab usually within one week. The dosimeters will display the name of the worker and may not be shared with others. When not being worn, dosimeters should be kept in the designated dosimeter storage location in the lab. If a dosimeter is ever lost or broken the RSO can issue a replacement.

Most often, two dosimeters will be issued-- a body dosimeter and a hand (ring) dosimeter. The body dosimeter should be worn on the torso of the body with the name side facing outward away from the body. The ring dosimeter should be worn underneath the glove and on the hand that is likely to receive the higher radiation dose from the operation to be performed (as determined by the worker). The ring should be positioned so that the side of the ring displaying the worker's name is facing the source of radiation. For example, if the palm side of the hand is more likely to receive a higher dose than the rest of the hand, the ring should be rotated so the name side of the ring is on the palm side of the hand.



The dosimeters do not protect a worker from radiation exposure. They will not provide any visible or audible warning when being exposed to radiation. They are essential, however, in tracking a worker's radiation dose and confirming that occupational dose limits are not exceeded.

At the end of each calendar quarter, EHS staff will deliver new dosimeters and collect old dosimeters for evaluation. The RSO will contact a worker if dosimeters indicate a dose exceeding 100 mrem during a calendar year (2% of the annual whole body dose limit). Upon request, workers will be provided with a written record of their radiation exposure history while working at UD.

Monitoring for Internal Contamination

Monitoring for a radiation dose due to internal radioactive contamination may be conducted if a worker is at risk of inhaling or ingesting radionuclides during the course of their radioactive material work. If, during its review of proposed radioactive material protocols, the Radiation Safety Committee determines there may be a risk then the use of a fume hood, enclosure or other closed system is typically required. The Committee may sometimes also require that monitoring for internal radiation exposure be conducted.



Protocols involving a risk of inhalation of radioactive material include-

- Use of a volatile radiochemical (e.g. NaI^{125})
- Processes that generate radioactive aerosols
- Animals injected with radioactive material
- Protocols purposely designed to generate a radioactive gas (e.g. $^{14}\text{CO}_2$)

To conduct internal monitoring when volatile forms of radioiodine are used, a thyroid bioassay measurement is conducted. The worker reports to the EHS office before and after each experiment and a radiation detector is used to measure any radiation emissions from the thyroid. This is used to determine the radiation dose to the worker's thyroid.



To conduct internal monitoring for radionuclides other than radioiodine, a urine bioassay is conducted. The worker submits approximately 10 mL of urine to EHS the day after the completion of the experiment and the urine is tested for radioactive material content. A dose to the worker can be calculated based on the concentration of radioactive material in the urine.

Most radioactive material experiments at UD can be safely conducted on the open benchtop without a risk of inhalation or ingestion of radioactive materials. Experiments involving the airborne release of radioactive materials can be safely conducted in properly functioning fume hoods. For these reasons, routine monitoring for internal contamination at UD is rarely required.

Monitoring for internal contamination is often conducted, however, during radiation incidents that involve skin contamination of a worker or the spill of a volatile radiochemical. EHS staff that respond to such incidents will determine the need for internal monitoring of workers depending on the circumstances of the incident.

Security of Radioactive Materials

Whenever radioactive materials are unattended by trained lab workers, they must be secured from unauthorized access. In practice this means that either-

- Doors to the lab must be locked whenever the room is vacant, or
- Radioactive material must be locked up within the lab using padlocks or other similar devices

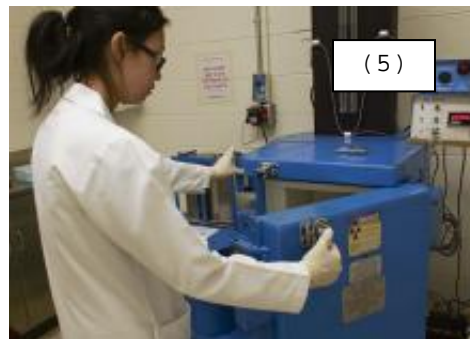
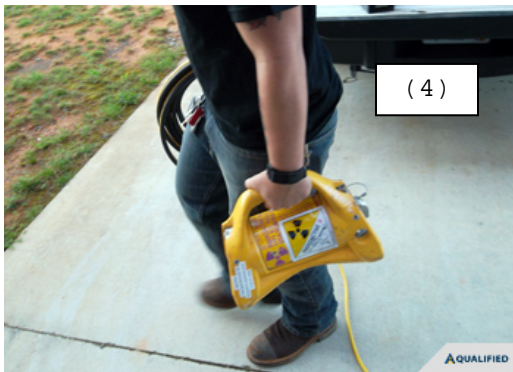
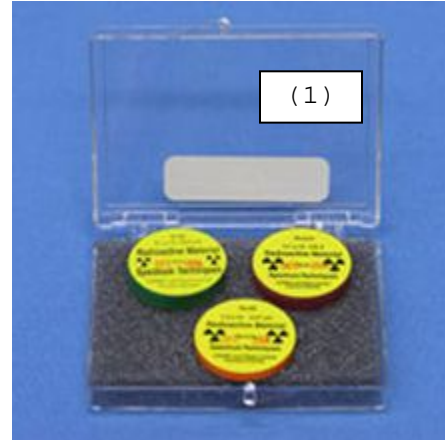
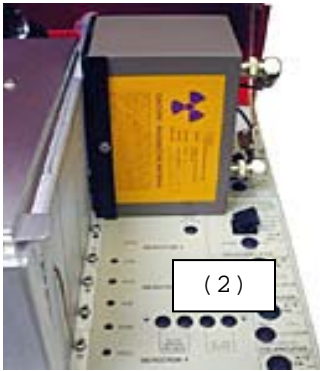
Strangers that enter labs where radioactive materials are used or stored must be challenged by lab workers. They may not be permitted to wander the lab unchecked.

It is the responsibility of the Permit Supervisor to train all lab workers (even those that are not radioactive material users) in this security requirement.



Sealed Radioactive Source Requirements

“Sealed sources” are items where the radioactive material is encapsulated or otherwise confined to prevent access. Examples include “button” check/calibration sources (1), electron capture detectors in gas chromatographs (2), aerosol ionizers (3), radiography sources (4), gamma irradiator sources (5).



If the source is distributed as a “license-exempt” source (e.g. some “button” sources), its acquisition and use is not controlled by the UD radiation safety program. This is because the radiation risk is minimal if used as designed. The owner is fully responsible for its safe use. When the source is no longer needed, it may be transferred to the EHS office for disposal. Workers should consult with the Radiation Safety Officer if they are uncertain if a source they are interested in acquiring is license-exempt.

All other sealed sources are controlled by the UD Radiation Safety Program in their acquisition, use, and disposal in the same fashion as unsealed sources. The requirements described throughout this Manual apply.

Special Requirements for Sealed Sources

- Sealed sources may only be used for their intended purpose.
- Opening the confinement of the radioactive source is never permitted.
- The radiation warning label on the source may not be hidden or defaced.
- If the warning label falls off or becomes illegible, the source must be taken out of service and the Radiation Safety Officer (RSO) must be notified.
- Shipping or transporting the source to another location for use or repair must be approved by the RSO who will most likely also handle all the arrangements for shipping.

Radioactive Material Spills and other Incidents

It is recommended that this information be posted in each radioactive material work area.

When responding to radiation incidents, the primary concern is the protection of personnel from radiation hazards. The secondary concern is the confinement of any radioactive contamination to the local area of the incident.

To summon help, use the emergency contact phone numbers which are posted on the warning signs at the entrances to every UD laboratory. Emergency call boxes/phones may also be used to summon assistance.

When reporting radiation incidents to UD Public Safety, remember always to state:

- Nature of the Radiation Incident
- Your Name
- Location where Assistance is Needed
- Whether the Radiation Safety Officer has already been Notified



Minor Spills of Liquids and Solids

- Notify persons in the area that a spill has occurred.
- Prevent the spread of contamination by covering the spill with absorbent paper. (Paper should be dampened if solids are spilled.)
- Wearing disposable gloves, lab coat, and eye protection, clean up the spill using absorbent paper.
- Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Put contaminated gloves and any other contaminated disposable material in the bag.
- Survey the area using an appropriate technique, e.g. radiation survey meter with pancake GM probe for P-32, radiation survey meter with gamma probe for I-125, wipe tests for low-energy beta emitters (H-3, C-14, S-35, P-33, Ca-45). Check the area around the spill for contamination. Also check hands, clothing, and shoes for contamination.
- Report the incident to the Radiation Safety Officer (RSO) promptly.
- Allow no one to return to work in the area unless approved by the RSO.
- Cooperate with the RSO and/or the RSO's staff during the post-incident investigation.
- Follow the instructions of the RSO and/or the RSO's staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

Major Spills of Liquids and Solids

- Instruct all persons not potentially contaminated by the spill to 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.

- 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 RSO immediately.
- In a safe area away from the spill but still in the room, 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. Use a sink in the lab for washing and not a restroom sink.
- Allow no one to return to work in the area unless approved by the RSO.
- Cooperate with the RSO and/or the RSO's staff during the spill clean-up and the post-incident investigation.

Incidents Involving Radioactive Dusts, Mists, Fumes, Organic Vapors, and Gases

- Notify all personnel to vacate the room immediately.
- If the incident occurred in a fume hood, close the hood window.
- Vacate the room and notify the RSO immediately.
- Ensure that all access doors to the area are closed and posted with radiation warning signs, or post guards at all access doors to prevent accidental opening of the doors or entry to the area.
- Survey all persons who could have possibly been contaminated. Decontaminate as directed by the RSO.
- Promptly report suspected inhalations and ingestions of licensed material to the RSO.
- Decontaminate the area only when advised and/or supervised by the RSO.
- Allow no one to return to work in the area unless approved by the RSO.
- Cooperate with the RSO and/or the RSO's staff during the post-incident investigation.
- Follow the instructions of the RSO and/or the RSO's staff (e.g., decontamination techniques, surveys, provision and collection of bioassay samples, requested documentation).

Minor and Controlled Fires

- If trained in the use of the fire extinguisher, attempt to put out the fire -- but only if there are no other fire hazards or radiation hazards present.
- Notify all persons present to vacate the area and have one individual immediately call the RSO and fire department.
- Once the fire is out, isolate the area to prevent the spread of possible contamination.
- Survey all persons involved in combating the fire for possible contamination.
- Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and then washing with a mild soap. If possible, use a sink in the lab for washing and not a restroom sink.
- In consultation with the RSO, determine a plan of decontamination and the types of protective devices and survey equipment that will be necessary to decontaminate the area.
- Allow no one to return to work in the area unless approved by the RSO.
- Cooperate with the RSO and/or the RSO's staff during the post-incident investigation.
- Follow the instructions of the RSO and/or the RSO's staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

Fires, Explosions, or Major Emergencies

- Notify all persons in the area to leave immediately.
- Pull fire alarm as you leave the building. Notify fire department by phoning 911. An emergency call box telephone may also be used.
- Notify the RSO and other facility safety personnel.
- Remain on the scene and report to the command post established by emergency responders (a green flashing light is often used to identify the post). Advise responders and the RSO regarding the nature of the fire.
- Cooperate with the RSO and/or the RSO's staff during the post-incident investigation.
- Allow no one to return to work in the area unless approved by the RSO.
- Follow the instructions of the RSO and/or the RSO's staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

Injuries to Personnel Involving Radiation Hazard

- For minor cuts/wounds involving radioactive contamination wash immediately under running water at lab sink. Notify the RSO as soon as possible and await arrival of RSO.
- For serious wounds and medical conditions, immediately obtain medical assistance by phoning 911 or using an emergency call box/phone. If qualified, administer first aid. Stay with injured person until help arrives. If you are the injured person, call out for help to others nearby. Inform emergency responders of any radioactive contamination that may be on or near the injured person and/or provide them with the contact phone number for the RSO. Notify the RSO as soon as the situation allows.
- Cooperate with the RSO and/or the RSO's staff during the post-incident investigation.

Known or Suspected Over-Exposure or Ingestion

- Any person who suspects over-exposure to radiation from any source must report immediately, by phone or in person, to the RSO.
- Any person who swallows, injects, absorbs, or otherwise ingests radioactive materials (excluding those which are a part of medical diagnosis or therapy) must report the intake immediately to the RSO.

Defects in Radiation Devices

- Whenever there is a failure of a safety component of a radiation device that may indicate a defect and could contribute to the exceeding of a safety limit, the user of that device must immediately notify the RSO. (Example: shutter preventing radiation from exiting a radiation device jams in the open position.)
- The RSO will then make an evaluation and report findings to the NRC Operations Center per the requirements of 10 CFR 21.21.

The Radiation Safety Officer (or another qualified emergency responder) may be reached-

- 1) directly during regular working hours at 831-8475 or
- 2) through the Department of Public Safety, 24 hours a day, at 831-2222.