



College of the Holy Cross

Radiation Safety Manual

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Reviewed annually by Radiation Safety Officer

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I. General Policies and Procedures

1. General Policy Statement

Radioactive materials are valuable tools for studying chemical, biochemical, and physical processes. At the same time radioactivity can be hazardous to human health if present at high exposure dosage. To ensure safety, federal and state agencies have established regulations, rules and safety practices to minimize the hazards to the user and to the members of the general public. Commonwealth of Massachusetts Department of Public Health regulation 105CMR120.000 and regulations by the U.S. Nuclear Regulatory Commission (NRC) apply to all persons who receive, possess, use, transfer, own, or acquire any source of radiation. This Manual sets forth the policy and procedures associated with the use of radioactive materials at the College of the Holy Cross.

2. Responsibilities

2.1 Radiation Safety Officer

The Radiation Safety Officer (RSO) is overseen by the Director of Physical Plant. The duties and responsibilities of the Radiation Safety Officer consist of:

- Establishing action levels of personnel exposure, radiation and contamination limits;
- Executing the policies of radiation safety as outlined the Radiation Safety Manual, and ensuring compliance with federal and state regulations;
- Conducting radiation safety training for personnel who will use radioactive materials;
- Assisting in storage, use and waste disposal problems;
- Monitoring users' procurement, storage, use, and disposal of radioactive materials;
- Responding to emergencies and decontamination operations by the authorized user;
- Conducting an annual inventory of all radioactive materials;
- Maintaining complete records that are in a form suitable for inspection by regulatory agencies.

2.2 Authorized User

The Authorized User is an individual authorized by the College license to use and supervise the user of radioactive materials and is responsible for:

- Implementing the policies and procedures of the Radiation Safety Manual;
- Minimizing radiation exposure to the registered user, environment, and general public;
- Ensuring those working under his/her Authorization satisfactorily completes radiation safety training;
- Ensuring that dosimeters are used;
- Maintaining records of procurement, inventory, surveys, and waste disposal.

2.3 Registered User

Persons who will use radioactive materials must:

- Register and complete radiation safety training prior to using any radioactive material;
- Comply with the conditions of the Authorized User;
- Wear assigned radiation dosimeter and any protective clothing;
- Handle and use radioactive materials to minimize radiation exposures;
- Complete a thorough personal and radiation survey of your work area after using radioactive materials.

3. Authorization

Any purchase, use or work with radioactive materials requires an individual to be listed on the College license as an Authorized User.

3.1 Evaluation for Authorization

For an individual to become an Authorized User, (s)he must have acceptable training and experience. In the evaluation process, the RSO will review:

- Types, amount, and proposed uses of radioactive materials;
- Education, training, and practical experiences commensurate with the radioactive materials to be used;
- Laboratory facilities including storage, survey, and safety devices;
- Waste disposal plan.

The individual must agree to abide by all policies and procedures for acquisition, use, storage and disposal of radioisotopes.

3.2 License Amendments

All requests for amendments must be submitted in writing to the RSO. Amendments include changes to possession limits, registered laboratories, and authorized users. The license will be amended at most once per year.

4. Pregnant or Potentially Pregnant Radiation Users

The Massachusetts Radiation Control Program has established a 500 mrem radiation dose limit to the embryo/fetus during the nine-month gestation period. If the user wishes to notify the RSO that they are either pregnant or trying to become pregnant, the RSO can provide additional monitoring program.

II. Radioactive Materials in Laboratories

1. Personnel Monitoring and Exposure Limits

1.1 Dosimetry Requirements

Personnel monitoring is done with radiation dosimeters worn by a person (badge, ring) or placed in an area to measure external radiation exposures (Geiger-Mueller counters). Dosimetry use ensures that radiation exposures are kept as low as reasonably achievable. **All radioactive material users and others who occupy radioactive material use areas must wear a radiation dosimeter.** Radioactive material users are monitored and the dosimetry results available from the Authorized User and the RSO. Contact the RSO for additional personal dosimeters. If you are working with any high-energy beta (e.g. ^{32}P), x- or gamma emitter (^{125}I), or x-ray diffraction unit you must also wear a thermoluminescent dosimeter finger ring.

1.2 Exposure Limits

State and Federal annual occupational exposure limits are shown in Table 1.

Table 1 Annual Exposure Limits

Type of Exposure	Annual Limit
Whole body, head and trunk, active blood forming organs (total effective dose)	5,000 mrem (50 Sv)
Lens of the eye	15,000 mrem
Skin, extremities	50,000 mrem
Embryo/fetus	500 mrem

Persons under 18 years of age are limited to maximum exposures of 1/10th of the above levels. Exposure to the general public (non-occupational) is limited to maximum level of 100 mrem/year.

2. Authorized Laboratories

2.1 2.1 General Requirements

Radioactive Materials may only be used in laboratories and rooms that are listed on the College license. An Authorized User may add a new laboratory by filing an amendment to the license. As part of the Authorization process, the RSO will review the laboratory space for the proposed purpose.

2.2 Posting of Signs and Labels

The Massachusetts Radiation Control Program regulations stipulate that all entrances to a laboratory that uses or stores radioactive materials or radiation generating devices shall be posted

with an appropriate caution sign. A list of isotopes and contact phone numbers of the Authorized User and RSO must be included on the sign. Emergency Procedures and phone numbers of the RSO and Authorized User must be posted in all radioactive materials use areas.

Mark laboratory equipment such as beakers, flasks, centrifuges, test tube racks and pipettes used for radiation work with a radiation symbol to minimize the potential for inadvertent contamination. Containers that may be used for transitory use of radioactive materials and will not be left in a contaminated state do not need to be posted if they are under the direct control of a registered user. Post all storage containers with a "Caution Radioactive Material" label that includes the radiation symbol, radionuclide, activity and reference date. Prior to disposal of any laboratory equipment or supplies that have been used with radioactivity, survey the material with an appropriate instrument to ensure that it is not contaminated and remove all radiation, radioactive materials and radiation symbols.

2.3 Radioactive Materials Security

All stock solutions, sealed sources and waste with more than trace quantities must be secured against unauthorized removal or access by locking the room or the container. Store radioactive materials only in areas designated on the license. Maintain an up-to-date Radioactive Materials Inventory.

Use one of the following methods of security:

- Store radioactive materials or radioactive waste in a locked container such as a freezer or other container that cannot be removed;
- Store radioactive materials in a locked room, such as an equipment room inside a laboratory;
- Liquid solutions may be secured by placing the material in a locked automated dispenser that cannot be removed from the laboratory;
- In case of loss or theft, notify the RSO immediately and Massachusetts Radiation Control Program at (617) 242-3035, Fax (617) 242-3453. Nuclear Incident Advisory Team (NIAT) Emergency Number (617) 242-3457.

2.4 Minors and Radioactive Materials

No person under 18 years of age is allowed into a laboratory containing radioactive materials unless the person is supervised by an Authorized User.

3. Procurement of Radioactive Materials

No one may order, receive, use, or bring into the College any radioactive material without prior authorization from the Radiation Safety Officer. This includes purchases from commercial vendors, other universities or transfers from colleagues or gratis shipments from commercial vendors.

3.1 3.1 Ordering Radioactive Materials

Only Authorized Users may order radioactive materials. Before ordering radioactive material, contact the Radiation Safety Officer. The RSO will review the current inventory of radioisotopes on hand to assure that maximum possession limit for the College will not be exceeded by the new order.

3.2 3.2 Receiving Radioactive Materials

Radioactive material package must be addressed to the Authorized User who ordered the material. Every effort should be made to ensure the Authorized User accepts the delivery. If the Authorized User is absent or unable to accept the delivery, s(he) may designate a trained Laboratory Supervisor to accept the delivery. If neither the Authorized User nor a Laboratory Supervisor can be present accept the delivery, contact the RSO to secure the package.

Every radioactive material package requires Department of Transportation (DOT) mandated external survey. The Authorized User or the Laboratory Supervisor who receives the package is responsible for completing the DOT required survey within 24 hours of receipt or the following business day using the Radioactive Material In-Coming Shipment Record.

Packages which show measurable contamination above background upon wipe testing must be decontaminated and then stored for 24 hours prior to retesting for surface contamination.

When opening the package, complete the following steps:

1. Put on protective gloves and a lab coat before proceeding with package receipt. Open the inner package, remove the stock vial with appropriate remote handling devices and verify that the contents agree in name and quantity with the packing slip and it is what you ordered. Contact the RSO if there is a discrepancy.
2. Wipe test the external surface of the stock material vial. Survey the wipe with a survey meter unless you are receiving ^3H . Use a liquid scintillation counter when monitoring for ^3H .
3. Treat all packaging material as potentially contaminated until surveyed and confirmed to be uncontaminated. Use a survey meter to monitor the package liner, shielding, radionuclide container and Styrofoam packing inserts for contamination before disposal in the regular trash. Contact the RSO if there is contamination.
4. If material has been delivered in dry ice, refrigerate immediately.
5. Deface the label on the package before discarding the empty box into the trash can.

3.3 3.3 Transfer of Radioactive Materials

Consult the RSO if radioactive material is to be transferred to another institution. Allow enough time for the RSO to work with the other institution's Radiation Safety Office and complete the appropriate paperwork.

4. Handling of Radioactive Materials

The radioactive materials come in either sealed or unsealed forms. People can be protected against excessive external radiation exposure from sealed sources by: a) placing absorbers (shield) in the path of the radiation to limit the amount reaching the body; b) working at a sufficient distance from the source; and c) minimizing the amount of time exposure to the source.

The exposure risk from unsealed sources would arise primarily from ingestion, inhalation, or skin contact. The protective measures used to prevent uptake of radioactive materials into the body are similar to those used in handling of other hazardous chemicals.

4.1 4.1 General Procedures

When working with either sealed or unsealed sources, everyone must follow these procedures:

- Wear a lab coat and gloves when handling radioactive materials. Wear a dosimeter badge.
- Never pipette by mouth (a practice to avoid in general);
- Students should not use isotopes in concentration higher than 100 microCuries/ml; ask your Authorized User to prepare such solutions from the more concentrated stocks;
- During periods that you are actively doing experiments with radioactive materials; see that the area you are using is monitored regularly. Monitoring includes using the count rate meter to detect higher than background levels of gamma radiation and swab testing (wiping with damp pieces of filter paper that are then placed in scintillation vials with scintillation fluid and counted) of all areas where isotopes have been handled. Values more than twice background should be reported to your Authorized User;
- If it is necessary to move isotope-labeled material from one laboratory to another, be sure that it is secured in a tightly closed container. It is not a good idea to move radioactive materials through unrestricted areas frequently;
- Use a fume hood for all manipulations involving fumes, volatile compounds or aerosols;
- Smoking, eating and drinking in areas posted as restricted because of radioactive material use is prohibited. Food and cosmetics must not be stored in those areas;
- Students may not use radioisotopes unless there is an Authorized User in the building at the time. In particular this means that experiments with isotopes should not be performed at night;
- When you are finished using radioactive material, be sure that the supply has been returned to its proper storage spot. At the end of the working day, lock the room;
- All persons working in areas when radioisotopes are used must complete the Personal Survey Form prior to leaving the work area and at the end of the day.
- Do not use radioactive materials in or on human beings or other animals. It is not a provision of our license.

Attention to these procedures will insure not only that you are not harmed by experimenting with radioactive materials but also that our license remains in effect. Actually a greater risk than the risk to your personal health is the risk to your experimental results if approved procedures are not followed: most of us use isotopes at levels too low to consider hazardous but well within the detection capabilities of our instruments.

4.2 4.2 Spills and Contaminations

In the event of a spill of radioactive material, isolate the involved area and notify the Radiation Safety Officer immediately. If the spill is minor (no radiation hazard to personnel), take the following steps:

1. **Notify:** Notify persons in the area that a spill has occurred.
2. **Personnel Decontamination:** If there is contamination on skin, gently wash with mild soap and water. If the material remains after several washings, contact the RSO. If you have reason to believe that you or someone may have inadvertently ingested or inhaled radioactive materials, immediately contact the RSO or your Authorized User for bioassay instructions. Remove any contaminated articles of clothing.
3. **Survey the Contamination:** Wear your dosimeter and the proper protective equipment: gloves, laboratory coat, eye protection, booties, etc. before attempting spill clean up. Use a G-M meter or a scintillation counter to survey the contaminated area to determine the extent. Look for any isolated spots.
4. **Clean Up:** Clean up using methods appropriate to the chemistry of the spilled material. Dispose clean-up material (e.g. paper towels) as radioactive waste if they contain more than 100,000 dpm/g of weak beta emitters or more than 200 dpm/g of stronger beta or gamma emitters.
5. **Re-Survey the Contamination:** Once finished with the decontamination, survey the area to make sure that have returned to background levels. Any area containing more than 200 dpm/100cm² will be posted as contaminated and cleaned up until it falls below those limits. Perform an extensive personal survey.

In case of a major spill, take the following steps:

1. **Clear the Area:** Notify all persons not involved in the spill to vacate the room.
2. **Prevent the Spread:** Cover the spill with absorbent material, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spread.
3. **Shield the Source:** If possible, the spill should be shielded, but only if it can be done without further contamination or without significantly increasing radiation exposure.
4. **Close the Room:** Leave the room and lock the door(s) to prevent entry.
5. **Call for Help:** Notify the Radiation Safety Officer and the Public Safety Department immediately.
6. **Personnel Decontamination:** Contaminated clothing should be removed and stored for further evaluation by the RSO. If the spill is on the skin, flush thoroughly and then wash with mild soap and lukewarm water. Injured persons should be decontaminated and first aid performed as necessary. If life threatening injuries are present, the individual should be given immediate life-saving first aid and transported to the hospital for further medical treatment regardless of any contamination present. The hospital should be given prior notification that the patient is contaminated so that the appropriate controls can be implemented.

5. Managing Radioactive Waste

Radioactive waste disposal can be a difficult and expensive process. In general, try to minimize waste by using materials with short half-lives or generating liquid waste that is water-soluble. Do not discard radioactive materials as ordinary trash. If the radioactive waste also contains a hazardous material, follow hazardous as well as radiological waste preparation standards.

5.1 5.1 Liquid Waste

Liquid wastes may be sink-disposed of only in designated sinks, and in quantities within the limits of Table III, Appendix B of 106 CMR 120 provided the wastes are readily soluble or dispersible in water. In general sink disposal should be followed by repetitive flushings with water. Records must be kept of disposal operations specifying the date, amount, activity, and the person responsible using the Radioactive Materials Sink Disposal Record that is posted near the sink.

If you are not certain whether the radioactive liquid is water-soluble, consult your Authorized User.

The RSO will collect the sink disposal logs and compile records on releases to the environment, as required by Federal and State regulations.

5.2 5.2 Solid Waste

Whenever possible, isotopes with relatively short half-lives, such as ^{32}P , ^{35}S , ^{125}I , etc., should be allowed to decay in storage for a period of at least 10 half-lives and then disposed of with normal trash after verifying that the radiation level is at background.

For all other waste, package the waste in a clear plastic bag, label the radionuclide, and contact the RSO to have the waste picked up.

6. Storage of Radioactive Materials

Radioactive materials and waste must be stored only in restricted areas approved by the Radiation Safety Officer. The Authorized Users is responsible for maintaining a current Radioactive Materials Inventory at all times and for providing a copy of the form every year at the request of the RSO. This inventory will include the radionuclide, physical form, amount of radioactivity, and location.

Authorized Users who store sealed sources must conduct a leak test every three months.

III. Appendix

Radioactive Material Information

The following materials are commonly used or found at Holy Cross.

Table 2 Licensed Materials at Holy Cross

Isotope	Major Radiation	Energy (keV)	Half Life	Detection Method
³ H	Beta	18.6	12.6 yrs	LSC
¹⁴ C	Beta	156	5730 yrs	GM, LSC
²² Na	Beta Gamma	545 511, 1,275	2.6 yrs	GM
³² P	Beta	1710	14 days	GM
³³ P	Beta	249	25 days	GM
³⁵ S	Beta	167	88 days	GM, LSC
³⁶ Cl	Beta	714	3.05 x 10 ⁵ yrs	GM
⁴⁵ Ca	Beta	252	165 days	GM
⁵⁷ Co	Gamma	14, 122, 136	271 days	GM
⁸⁶ Rb	Beta Gamma	1780 1078	18.6 days	GM
¹⁰⁹ Cd	Beta Gamma	63, 84 22, 88	464 days	GM
¹²⁵ I	Gamma	28, 31	60 days	NaI
¹³³ Ba	Gamma	81, 356	10.5 yrs	GM
¹³⁷ Cs	Beta Gamma	157, 415 662	30.2 yrs	GM
²⁴¹ Am	Alpha Gamma	5,500 14, 60	430 yrs	LSC, GM

LSC – Liquid Scintillation Counter

GM – Geiger-Mueller Meter

NaI – Sodium Iodide

Radioactive Material In-Coming Shipment Record

College of the Holy Cross

To remain in compliance with our Radioactive Materials License issued by the Massachusetts Radiation Control Program, A survey must be conducted upon the receipt of every shipment of radioactive materials. Please completely fill out and sign this form, and promptly forward it to the Radiation Safety Officer.

Licensed User's Name:			
Department:			
Lab Location:			
Radioactive Isotope:			
Radioactivity:	mCi or μ Ci (circle one)		
Manufacturer:			
Description of the Product:			
Date Received:			
Does the packing slip describe the item ordered?	Yes	No	
Is the package damaged or leaking? (If yes, contact the Radiation Safety Office immediately.)	Yes	No	
Survey results:			
Count rate survey of unopened package:			
Count rate survey of package contents at the surface the container:			
Count rate survey of packing materials:			
Signature:		Date:	

SINK DISPOSAL RECORD FORM

Authorized User: _____

Building/Room: _____

Sink Disposal Limits ($\mu\text{Ci}/\text{liter}^1$)			
^3H	100	^{14}C	3.0
^{32}P	0.9	^{33}P	8.0
^{35}S	10	^{125}I	0.2

¹ as 10 times 105 CMR 120 Appendix B, Table III

*****IMPORTANT!!! PLEASE EXPRESS AMOUNT ONLY IN μCi *****

Date: M/D/Y	User	Radioisotope	Activity

****PLEASE WRITE LEGIBLY. ****

Personal Survey Form

Authorized User: _____

Building/Room: _____

- DIRECTIONS:**
1. Hands and working areas should be surveyed after each use of radioactive materials.
 2. Wipe tests are required for ^3H .
 3. Forms should be kept for record. Notify the Radiation Safety Officer if any personal contamination is detected.

Date: M/D/Y	User	Isotope	Survey Meter Reading	
			Hands and Clothing	Working Areas

Radioactive Materials Inventory

Authorized User: _____

Building/Room: _____

Radioisotope: _____

Original Activity (μCi): _____

Total Original Volume (μl): _____

Concentration ($\mu\text{Ci}/\mu\text{l}$): _____

Date Used: M/D/Y	User	Amount Used	Amount Remaining

Radiation Safety check list	Interval
Ordering Radioactive Materials	As needed
Prior to placing the order, request approval from RSO	
Once approved, submit order to supplier	
Authorized user is the recipient of the order	
Receiving Radioactive Materials	Within 24 hrs after receiving package
Authorized user or trained laboratory supervisor accepts delivery	
Authorized user must wear gloves, coat, and dosimeter badge when handling	
Confirm the package is not damaged or leaking	
Use survey meter or scintillation counter to test external surface of package, packing materials, package contents at surface of container and record all results	
Verify contents of package and compare to order form	
Deface label on package material before discarding	
Contact RSO if contamination is present	
In-coming Shipment Form	As needed
When package is received, fill out the In-coming Shipment Form	
Form includes the count rate survey data from above procedure	
Submit to RSO at time of delivery or at least monthly	
Dosimeter Badges	Quarterly
Dosimeter badges must be worn when handling radioactive materials	
Thermoluminescent dosimeter ring badge required for use with high-energy beta (P32) or gamma emitter (I125) or x-ray diffraction unit in addition to dosimeter badge	
RSO orders and returns badges for processing and maintains records	
Inspections of laboratories by RSO	
Inspections will be done each time the dosimeter badges are distributed	Quarterly
Sealed Source Leak Test	Quarterly
Authorized user conducts wipe tests	
RSO orders and returns swabs for analysis and maintains records	
Personal Survey Form	Monthly
When handling radioactive materials, wear coat, gloves and dosimeter badge	
Area must be monitored regularly when doing experiments with radioactive materials	
Monitoring- survey meters for gamma or wipe tests with scintillation counter for tritium	
in all areas where isotopes have been handled. Values more than twice background -	
contact Authorized user.	
Personal Survey Form must be filled out prior to leaving the work area or at end of day	
Submit forms monthly to RSO	
Radioactive Waste Handling	When needed
Liquid waste: if water soluble, discard in designated sink with repetitive flushing	
Keep a record of the material and activity (Sink Disposal Form - see below)	
Liquid waste: insoluble in water, place in bottle with clearly labeled information	
Contact RSO for pickup	
Solid waste: Relatively short half-life materials -P32, S35, I125 etc.	
allow to decay for at least 10 half-lives, then place in trash	
Other waste, contact RSO for pickup	

Sink Disposal Record Form	Monthly
Record when any amount of radioactive material is disposed of down the drain	
Specify date, amount, activity, and person's name	
Submit to RSO monthly	
Radioactive Materials Inventory	Yearly
Complete list of all radioactive materials must be maintained at all times	
Submit Radioactive Materials Inventory form to the RSO each year when requested	
Training Authorized Users and Registered Users	Yearly
Authorized users must attend a yearly training session conducted by the RSO	
Registered users must be trained by Authorized users before work can begin	
Calibration of Survey Meters	Yearly
Survey meters must be calibrated yearly	
Submit calibration report to RSO	
Storage of Radioactive Materials	
Only store in restricted areas approved by RSO	
Spills and Contamination	
Minor spill(no radiation hazard)	
Notify others in area. Contamination on skin, wash with soap and water.	
Remove contaminated clothing	
Survey the contamination- have on badge, gloves, glasses and coat	
Use survey meter or scintillation counter to determine extent of contamination	
Dispose of clean up materials (paper towels) as radioactive waste if more than 100,000 dpm/g of weak beta emitters or 200 dpm/g of strong beta or gamma emitters.	
Re-survey the area, continue to clean until levels are less than 200 dpm/100 sq cm	
Major spill - notify others to evacuate room, cover spill with absorbent material, but don't attempt to clean. Leave room and lock door.	
Contact RSO and Public Safety.	
Radioactive Materials Security	
Keep doors or containers locked at all times	
Store only in designated areas.	
Authorized Laboratories and Postings	
Must be listed on the license, new areas will require amendment to license.	
An appropriate sign must be on the door with emergency procedures and phone numbers of RSO and authorized user.	
Post all storage containers with Caution Radioactive Material: label includes the radiation symbol, radionuclide, activity and reference date	
Other Rules	
Never pipet by mouth	
Students should not use isotopes in concentrations higher than 100 microCuries/mL	
When moving radioactive materials to another lab, secure in tightly sealed container	
It is not advisable to move materials through unrestricted areas frequently	
Use fume hood for all manipulations involving volatile compounds or aerosols	
Students may not use radioisotopes unless there is an Authorized User in building	
Do not use radioactive materials in or on humans or animals.	

References

Code of Federal Regulations. 10 CFR Part 20.

Massachusetts Regulations for the Control of Radiation, 105 CMR 120.

Shapiro, J., Radiation Protection. A Guide for Scientists and Physicians, Harvard University Press, Cambridge, Massachusetts, 1990.

Harvard University Radiation Safety Manual.

Boston University Radiation Safety Manual.

WPI Isotope Training Notes.

U.S. Nuclear Regulatory Commission Regulatory Guide Series:

NUREG 0247. Principles and Practices for Keeping Occupational Radiation Exposure at Medical Institutions as Low as Reasonably Achievable.

Regulatory Guide 8.10, Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable.

Regulatory Guide 8.18, Information Relevant to Ensuring that Occupational Radiation Exposures at Medical Institutions Will Be as Low as Reasonably Achievable.

Regulatory Guide 8.23, Radiation Safety Surveys at Medical Institutions.

Regulatory Guide 10.8, Guide for the Preparation of Applications for Medical Programs.