



RADIOACTIVE MATERIALS AND X-RAY EQUIPMENT SAFETY MANUAL

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1. REGULATIONS AND PROCEDURES

This section describes the policies and procedures to be followed by all faculty, staff, and students at State University of New York at Binghamton in the ordering, receipt, storage, use, and disposal of radioactive materials. This manual supersedes all other university documents related to radiation safety. A notice of the existence of the Safety Manual will be announced via the online campus wide daily news feed at the beginning of each Fall semester. A copy of the Safety Manual will be sent to all users of radioactive materials and is available on the Research Compliance website [Radiation Safety page](#).

A. *Radiation Safety Committee (RSC)*

The Radiation Safety Committee (RSC) operates under New York State Department of Health (NYSDOH) Radioactive Materials Licenses #588 and #5902. Initial use of radioactive materials by faculty or staff (Principal Investigators) must be approved the NYSDOH as part of the license. Principal Investigator wishing to use radioactive materials must submit a protocol to the RSC for review and approval. Once approved, the RSO will submit a license amendment request to the NYSDOH if the Principal Investigator has not yet been approved to use the identified radioactive isotopes.

Upon approval by the NYSDOH and the RSC, the Principal Investigator will be informed as to maximum limits. A maximum limit for stock pulse stored as waste will be set by the RSC.

Responsibilities

- i. Ensuring that all individuals who work with or near radioactive material have sufficient training and experience to enable them to perform their duties safely, and in accordance with New York State Department of Health regulations and the conditions of this license.
- ii. Ensuring that all use of radioactive material is conducted in a safe manner and in accordance with New York State Department of Health regulations and the conditions of the license.
- iii. Be familiar with all pertinent New York State Health Department regulations, the terms of the license, and information submitted in support of the request for the license and its amendments.
- iv. Review the training and experience of all individuals who use radioactive material and determine that their qualifications are sufficient to enable them to perform their duties safely and in accordance with New York State Health Department regulations and the conditions of the license.
- v. Be responsible for monitoring the institution's program to maintain individual and collective doses as low as reasonably achievable.
- vi. Review semi-annually, with the assistance of the Radiation Safety Officer (RSO), occupational radiation exposure records of all personnel working with radioactive materials.

- vii. Establish a table of investigational levels for occupational radiation exposure, which when exceeded, will initiate an investigation and consideration of action by the RSO.
- viii. Establish a program to ensure that all individuals whose duties may require them to work in the vicinity of radioactive material (e.g., security, custodial, facilities) are properly instructed as required by Section 16.13, New York State Sanitary Code (10 NYCRR 16).
- ix. Review and approve all requests for use of radioactive material within the institution.
- x. Prescribe special conditions that will be required during a proposed use of radioactive material such as requirements for bioassays, physical examination of users, and special monitoring procedures.
- xi. Review the entire radiation safety program, at least annually, to determine that all activities are being conducted safely and in accordance with New York State Health Department regulations and the conditions of the license. The review shall include an examination of all records, reports from the RSO, results of New York State Health Department inspections, written safety procedures, and the adequacy of the institution's management control system.
- xii. Recommend remedial action to correct any deficiencies identified in the radiation safety program.
- xiii. Maintain written records of all RSC meetings, actions, recommendations, and decisions.
- xiv. Ensure that the radioactive materials license is amended, when necessary, prior to any changes in facilities, equipment, policies, procedures, radioactive material, possession limits, and personnel, as specified in the license.
- xv. The RSC shall meet as often as necessary to conduct its business, but not less than once in each semester of the academic year. A quorum shall consist of at least one-half of the RSC membership, and must include the RSO and the management representative.
- xvi. RSC members will neither review nor vote upon any research protocol for which they have a conflict of interest. A member may be asked to provide the RSC information concerning the research; however, shall recuse for the final discussion and vote of all such studies, and are not counted toward quorum.
- xvii. Minimizing radiation exposures and for proper storage and disposal of radioactive materials rests with the faculty or staff member using such materials. This responsibility includes user orientation and indoctrination of the hazards involved, and on applicable procedures by which they may conduct their work safely over and above training provided by the RSO before work with radioactive materials began.

B. Training

Personnel will be instructed 1) before assuming duties with, or near, radioactive material; 2) during annual refresher training; and 3) whenever there is a significant change in duties, regulations, or the terms of the license Instruction for individuals in attendance will include the following subjects:

- i. Applicable regulations and license conditions.
- ii. Areas where radioactive material is used or stored.
- iii. Potential hazards associated with radioactive material in each area where the employees will work.

- iv. Appropriate radiation safety procedures.
- v. Licensee's in-house work rules.
- vi. Each individual's obligation to report unsafe conditions to the RSO.
- vii. Appropriate response to emergencies or unsafe conditions.
- viii. Worker's right to be informed of occupational radiation exposure and bioassay results.
- ix. Locations where the licensee has posted or made available notices, copies of pertinent regulations and the Safety Manual, and copies of pertinent licenses and license conditions (including applications and applicable correspondence), as required by Section 16.13, New York State Sanitary Code (10 NYCRR 16).

C. Records for Training Documentation

Records of initial and refresher training will be maintained for five years and will include:

- i. The name of the individual who conducted the training;
- ii. The names of the individuals who received the training;
- iii. The dates and duration of the training session; and
- iv. A list of the topics covered.

D. Radiation Safety Officer (RSO)

The Vice President for Operations makes the appointment of the RSO. The RSO's duties, responsibilities, and authority for ensuring radiological safety as follows:

- i. General surveillance over all activities involving radioactive material, including routine monitoring and special surveys of all areas in which radioactive material is used and stored.
- ii. Determining compliance with rules and regulations, license conditions, and the conditions of project approval specified by the RSC.
- iii. Monitoring and maintaining absolute and other special filter systems associated with the use, storage or disposal of radioactive material.
- iv. Furnishing consulting services on all aspects of radiation safety to personnel at all levels of responsibility.
- v. Receiving, delivering, and opening all shipments of radioactive material arriving at the institution and receiving, packaging, and shipping all radioactive material leaving the institution.
- vi. Meeting facilities and custodial staff at the beginning of each academic year to brief on procedures to be followed in labs where the radioactive symbol is displayed.
- vii. Distributing and processing personnel monitoring equipment, determining the need for bioassays, keeping personnel exposure and bioassay records, and notifying individuals and their supervisors of exposures approaching maximum permissible amounts and recommending appropriate remedial action.
- viii. Conducting training programs and otherwise instructing personnel in the proper procedures for the use of radioactive material prior to use, at periodic intervals (refresher training), and as required by changes in procedures, equipment, regulations, etc.
- ix. Supervising and coordinating the radioactive waste disposal program, including keeping waste storage and disposal records, and monitoring effluents.

- x. Storing all radioactive materials not in current use, including wastes.
- xi. Performing leak tests on all sealed sources.
- xii. Maintaining an inventory of all radioisotopes at the institution and limiting the quantity of radionuclides at the institution to the amounts authorized by the license. The inventory should include the name of the person responsible for each quantity of radioisotope, where it will be used or stored, and the date the quantity was delivered to that person. Items are removed from the inventory by showing how and when the radioisotope was disposed of.
- xiii. The RSO has the authority to terminate immediately, any project that is found to be a threat to health or property. The RSO will inform the Management Representative on the RSC and the Assistant Vice President for Research Compliance of any actions to terminate a project as soon as is possible.
- xiv. Check all sealed sources, interlocks and x-ray machines not less than once every six months.
- xv. Maintaining other records not specifically designated above (e.g., receipt, transfer, and survey records as required by Section 16.14 of 10 NYCRR 16).

2. ACQUISITION, STORAGE, AND CONTROL

A. Procurement

- i. The RSO must approve all orders for radioactive materials and will ensure that the requested materials and quantities are authorized by the license and that possession limits are not exceeded. All orders must have prior approval of the RSO.
- ii. Written records will be used that identify the isotope, compound, activity levels, and supplier; referenced when opening or storing radioactive shipments; and maintained for all ordering and receipt procedures.
- iii. During normal working hours, carriers will be instructed to deliver radioactive materials directly to Patrick Reardon, RSO, at Radioactive Materials Storage Building, Building 133 (behind Science II).
- iv. During off-duty hours, security personnel or other designated individuals will accept delivery of radioactive packages in accordance with the procedures outlined in the license.

B. Receipt

- i. All packages labeled "Radioactive Material" received by mail or by personal carrier will be delivered to the RSO, at Radioactive Materials Storage Building, Building 133 (behind Science II).
- ii. The RSO will receive and record all radioactive materials delivered to State University of New York at Binghamton and forward the material to the addressee. It is imperative that the RSO know at all times the type, quantity, and location of radioactive materials received. This regulation also applies to instruments including radioactive material or generating radiation, e.g., gas chromatographs and x-ray equipment.

C. Opening Packages Containing Radioactive Material

- i. Special requirements will be followed for packages containing quantities of radioactive material in excess of the A quantities specified in 49 CFR 173.435. They will be monitored for surface contamination and external radiation levels within 3 hours after receipt if received during working hours or within 18 hours if received after working hours, in accordance with the requirements of Section 16.16 (a) and (e), New York State Sanitary Code (10 NYCRR 16). The Department will be notified in accordance with the regulations if removable contamination exceeds 0.01 uCi/100 square centimeters (22,000 dpm) or if external radiation levels exceed 200 mR/hr at the package surface or 10 mR/hr at 3 feet (or 1 m).
- ii. For all packages, the following procedures for opening packages will be carried out:
 - a. Put on gloves to prevent hand contamination.
 - b. Visually inspect package for any sign of damage (i.e., wetness, crushed). If damage is noted, stop procedure and notify Radiation Safety Officer.
 - c. Measure exposure rate at 3 feet (or 1 m) from package surface and record. If it is higher than usual, stop and notify the Radiation Safety Officer.
 - d. Open the package with the following precautionary steps:

- Open the outer package (following manufacturer's directions, if supplied) and remove packing slip.
 - Open inner package and verify that contents agree with those on packing slip. Compare requisition, packing slip and label on container.
 - Check integrity of final source container (i.e., inspect for breakage of seals or vials, loss of liquid, or discoloration of packaging material).
- e. If there is any reason to suspect contamination, wipe external surface of final source container and remove wipe to low background area. Assay the wipe and record amount of removable radioactivity (i.e., dpm/100 square centimeters, etc.). Check wipes with a thin-end window GM survey meter, and take precautions against the spread of contamination as necessary.
- f. Monitor the packing material and packages for contamination before discarding.
- If contaminated, treat as radioactive waste.
 - If not contaminated, obliterate radiation labels before discarding in regular trash.
- g. Maintain records of the results of checking each package, using "Radioactive Shipment Receipt Record" or a form containing the same information.

D. Storage

All radioactive material, regardless of activity, will be stored in a locked facility when no activities are in progress relating to the use of the radiation source. All containers in storage facilities should be properly labeled at all times. NEVER LEAVE RADIOACTIVE MATERIALS IN A LABORATORY UNATTENDED; IF YOU HAVE TO LEAVE, THE DOOR MUST BE LOCKED.

E. Use

All use of radioactive materials for research or instructional purposes by faculty, staff, or students must be cleared with the RSC. Prior to starting any experiments with radioactive isotopes, the faculty and staff must apply to the RSC for a license issued by the NYSDOH (see section A.). Only full-time faculty and staff may apply for a license. All other users must work under the supervision of an approved faculty or staff member. Those who have not used radioactive materials in the last 24 months must be reinstated on the list of licensed users and must submit a new protocol for Permission to Order and Use Radioactive Materials and X-Ray via the [Pre Award and Compliance System \(PACS\)](#).

A fume hood with a minimum air flow of 100 cfm is REQUIRED when the activity of the radioactive materials in use is 10% of the bioassay action levels listed in the U.S. NRC Regulatory Guides 8.20 and 8.32, or when the RSO determines that a hood is required. The RSO will review the experimental protocol, chemical and biological forms of the materials to be used, the isotopes and the experience and training of the users.

F. Steps to Obtain Approval

- i. Complete the Protocol for Permission to Order and Use Radioactive Materials and X-ray Equipment via PACS. Any questions pertaining to the completion of your Protocol should be addressed to the Research Compliance Office at rescomp@binghamton.edu or at (607) 777-3822. You may also contact the RSO at (607) 777-3589 for specific questions regarding your use and research.
- ii. The RSC reviews the proposal.
- iii. The applicant is notified by the Research Compliance Office on behalf of the RSO and RSC Chair of approval, required modification(s), or denial.
- iv. If approved, the applicant is notified of any conditions and maximum limits.
- v. Applicant orders of the radioactive isotope(s) approved by the RSC are to go through the RSO.
- vi. If a film badge is required, it will be provided by the RSO.

G. Record of Use

Radionuclide Use and Disposal Records will be maintained by each faculty and staff member using radioactive materials. This form should include: name of isotope, date received, storage area, activity (amount) and manner of disposal. The inventory record and use and disposal records will be submitted to the RSO semiannually in September and February and at any other time at the request of the RSO. Failure to maintain these records and submit them promptly can result in suspension of permit to use radioactive materials. The information can be submitted via PACS as an amendment to your protocol. Further information is available from the RSO or from the Research Compliance Office.

H. Enforcement Procedure

- i. When the RSO determines that a University radiation material licensee does not comply with a rule or regulation and that this noncompliance threatens health or property, the RSO will:
 - a. Suspend or terminate the program immediately.
 - b. Report immediately to the Chair of the RSC and the Assistant Vice President for Research Compliance.
 - c. The RSC will review the action of the RSO and take additional action, as necessary.
 - d. When the RSO determines that a licensee does not comply with a rule or regulation and that this noncompliance does not threaten health or property, he will notify the licensee and assist in taking corrective action within the time specified by the RSO.
 - e. If corrective action is not taken within the time specified by the RSO, written notice will be given to the user with carbon copy to the Chair of the RSC.
 - f. The RSC will notify the licensee that the license will be suspended if corrective action is not taken within a specified time. (The specific time will be 30 days or less depending on the nature of the noncompliance).

I. Annual Audit and Program Review

The Annual Review of our Radiation Safety Program will consist of, but NOT necessarily be limited to:

- i. An examination of records:
 - a. Exposure records
 - b. Laboratory surveys
 - c. Training records and programs
 - d. Meter calibration
 - e. Incident reports
 - f. Waste management
 - g. Receipt of radioactive materials
 - h. Review of quarterly inspections
 - i. Inventory report
- ii. Reports from the RSO
- iii. Discussion of results of New York State Health Department inspection
- iv. Discussion of written Safety Procedures
- v. Discussion of adequacy of Management Control System

J. Radiation Survey

- i. It is recommended that these surveys be done by the students who are working with radioactive materials and should become a part of their training in the safe handling of radioactive materials.
- ii. Laboratory areas where only small quantities of radioactive material are used (less than 200 uCi) will be surveyed monthly.
- iii. Waste storage areas and all other laboratory areas will be surveyed weekly.
- iv. The weekly and monthly surveys will consist of:
 - a. A measurement of radiation levels with a survey meter sensitive enough to detect 0.1 mR/hr.
 - b. A series of wipe tests to measure contamination levels. The method for performing wipe tests will be sensitive enough to detect 1000 dpm per 100 square centimeters for the contaminant involved. Wipes made of "high background" areas will be removed to a low background area for measurement.
- v. A permanent record will be kept of all survey results, including negative results. The record will include:
 - a. Location, date, and identification of equipment used, including the serial number and pertinent counting efficiencies.
 - b. Name of person conducting the survey.
 - c. Drawing of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.
 - d. Measured exposure rates, keyed to a location on the drawing (point out rates that require corrective action).
 - e. Detected contamination levels, keyed to locations on drawing.
- vi. Area will be cleaned if the contamination level exceeds 2000 dpm/100 square centimeters.

- vii. For Gamma Emitters, a smear survey is to be used for high sensitivity.
 - a. Use filter paper about one inch in diameter.
 - b. Smear an area of >100 cm².
 - c. Count the filter paper with a sodium iodide, liquid scintillation or G.M. Counter equipped with a scalar. Use the appropriate detector (e.g., a G.M. Counter is useless for tritium, (H-3)).
 - d. G.M. Survey is to be used when immediate information is needed and precision is not important, as it indicates the presence of contamination only.
- viii. Ionization Chamber Survey is used for high precision and low sensitivity.
- ix. For Beta Emitters, a smear survey is to be used for highest sensitivity.
 - a. A must for H-3 and will detect other beta emitters.
 - b. Use filter paper about one inch in diameter.
 - c. When possible smear an area of 1,000 cm² or more.
 - d. Place each filter paper (H-3) in a vial containing liquid scintillation counting solution and count, or use a high sensitivity G.M. counter for C-14 and other beta emitters.
 - e. For high energy beta a G.M. Counter equipped with a scalar may be used.
 - f. G.M. Survey for immediate information, use with a thin window probe (note: this method is poor for C-14 and useless for H-3).

K. Decontamination

Decontamination can usually be accomplished by washing with soap or detergent and water. Dilute acid or base or other strong cleaning agent may be required depending upon the chemical form of the contamination, and the nature of the surface. The materials used in decontamination should be disposed of as solid waste.

Decontamination efforts should be continued until a smear taken on the surface indicates less than 1000 dpm of removable beta/gamma emitting material is present per 100 cm² in a controlled area. For G.M. Survey, indicate whether contamination is present and model of meter used. Surface contamination should be kept as close to background as possible and should never exceed the following limits:

RADIOACTIVE SURFACE CONTAMINATION LIMITS

Application	Alpha		Beta/Gamma	
	Total (mR/hr)	Removable (dpm/100cm ²)	Total (mR/hr)	Removable (dpm/100cm ²)
Controlled area				
Basic guide	25,000 Max. 5,000	500	1.0	5,000
Clean area	1,000	100	0.5	1,000
Non-controlled area				
Skin, personal clothing	500	N.D.	0.1	N.D.
Release of material or facilities	25,000 Max. 500 Av.	100	0.2	1,000

Measured at 1 cm from the surface

N.D.--non-detectable

Anytime a smear or survey indicates contamination greater than twice the background, the area should be decontaminated.

L. General

- i. Rules for Safe Use of Radioactive Material: These rules must be posted as required by Section 16.13 (b), New York State Sanitary Code (10 NYCRR 16).
 - a. Prior to performing operations with quantities of radioactive material which may produce significant external or internal exposure, attention shall be given by the user to precautionary measures including the use of remote handling devices, hoods, shielding, etc. The RSO must be consulted before beginning any new use of radioactive material.
 - b. There shall be no eating, drinking, applying cosmetics, or preparation of food in any location where unsealed sources of radioactive materials are used or stored.
 - c. Smoking is prohibited in all state buildings. Binghamton University is a Tobacco-Free campus.
 - d. Do not store food, drink, or personal effects with radioactive material.
 - e. Pipetting of radioactive solutions by mouth is prohibited.
 - f. Segregate pipetting devices used with radioactive materials from those used with non-radioactive solutions.
 - g. Lab coats and disposable gloves shall be worn during operations involving the handling of unsealed sources of radioactive material. The lab coat and gloves should be removed before leaving the laboratory. Care must be taken such that other items (e.g., pens, pencils, notebooks, door knobs, telephones, etc.) are not handled with gloves used during work with radioactive materials.

- h. Work which may result in contamination of work surfaces shall be done over plastic-backed absorbent paper. Trays made of impervious materials (i.e., stainless steel, porcelain-coated, etc.) and lined with absorbent paper provide excellent work arrangements to help prevent the spread of contamination.
- i. Work surfaces and personnel must be monitored after working with radioactive materials.
- j. Where there may have been a spill of radioactive material (see posted Spill Procedures) which may have produced contamination of the person or clothing, both the person and the clothing shall be monitored. Personnel contamination shall be removed as soon as possible. Where contamination above action levels is noted during a laboratory survey decontamination must be immediately initiated by the user.
- k. After working with unsealed sources of radioactive material, hands should be monitored and washed before leaving the laboratory.
- l. Objects and equipment that may have been contaminated with radioactive material shall be surveyed and demonstrated to be free of contamination prior to their removal from a laboratory, or transferred to other laboratories, repair shops, surplus, etc. If found to be contaminated, such items must be decontaminated as soon as practical.
- m. If personnel monitoring devices (whole-body or ring badge) have been issued to you for your work with radioactive material, they must be worn at all times when in areas where these materials are used or stored. These devices should be worn as prescribed by the RSO. Personnel monitoring devices should be stored in a designated low background area when they are not being worn to monitor occupational exposures. They should not be left on your lab coat or shared by another individual.
- n. Dispose of radioactive waste only in the manner designated by the RSO and maintain records as instructed.
- o. Store radioactive materials in covered containers plainly identified and labeled with name of compound, radionuclide, date, activity, and radiation level, if applicable.
- p. Always transport radioactive material in shielded containers.

M. Personnel Monitoring

Personnel monitoring devices should be provided for individuals who are exposed to sources of whole-body radiation, or who handle millicurie quantities of energetic beta or gamma-emitting radionuclides.

- a. The Radiation Safety Officer will promptly review all exposure reports to look for workers or groups of workers whose exposure is unexpectedly high or low. This procedure does not apply to backup monitor records (e.g., pocket ionization chambers, when the monitor of record is a film or TLD).
- b. All individuals who are occupationally exposed to radiation on a regular basis will be issued a film or TLD whole body monitor that will be processed by a contract service on a monthly basis. This service must be accredited under NVLAP (a voluntary program for determining that a dosimetry service meets ANSI standards).

- c. All individuals who handle radioactive material on a regular basis will be issued a film or TLD finger monitor that will be processed by a contract service on a monthly basis.
- d. All individuals who are occupationally exposed to radiation on an occasional basis will consult with the Radiation Safety Officer concerning personnel monitoring before using radioactive materials.
- e. Other individuals who are exposed to radiation on an occasional basis, such as security personnel who deliver packages, will not normally be issued exposure monitors.

N. *Occupational Dose Limits*

https://www.health.ny.gov/environmental/radiological/radon/radioactive_material_licensing/docs/part16.pdf

- i. Adults: No person shall transfer, receive, possess or use any radiation source so as to cause any individual adult to receive an occupational dose from all sources of radiation that exceeds the annual limit.
 - a. The more limiting of the total effective dose equivalent being equal to 0.05 Sv (5 rem); or
 - b. The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 0.50 Sv (50 rem).
 - c. The annual limits to the lens of the eye, to the skin, and to the extremities which are an eye dose equivalent of 0.15 Sv (15 rem), and a shallow dose equivalent of 0.50 Sv (50 rem) to the skin or to any extremity.
- ii. Minors (Individuals less than 18 years of age): The annual occupational dose limits for minors are 10 percent of the annual occupational dose limit for adult workers.
- iii. Embryo/Fetus
 - a. The dose to an embryo/fetus during the entire pregnancy, which results from occupational exposure of a declared pregnant woman, does not exceed 5 mSv (0.5 rem). Past exposure history will be examined to adjust working conditions so as to avoid a monthly total effective dose equivalent of more than 50 mrem to the embryo/fetus of a declared pregnant woman.
 - b. The dose to an embryo/fetus shall be taken as the sum of the deep dose equivalent to the declared pregnant woman during the entire pregnancy period; and the dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman during the entire pregnancy period.
 - c. Declaration of pregnancy is voluntary and must be done in writing. If you are pregnant and wish to declare, you should send a written statement to the RSO.
- iv. Individual Members of the Public
 - a. The dose in any unrestricted area from external sources does not exceed 0.02mSv (0.002 rem) in any one hour.

O. *Animal Research Using Radioactive Material*

- i. Faculty or staff wishing to work with animals containing radioactive materials must submit a protocol to the RSCRSC for permission prior to obtaining permission from the Institutional Animal Care and Use RSC. When the RSC reviews an application, it will require and or consider the following:
 - a. All cages and trays must be labeled with the appropriate label and signs.
 - b. Animal waste and animal carcasses must be treated as radioactive waste.
 - c. How animal waste and animal carcasses will be stored and disposed of.
 - d. Disposable cages must be treated as radioactive waste.
 - e. Non-disposable cages and equipment used in caring for radioactive animals may not be returned to general use prior to decontamination and written approval of the RSO.
- ii. The method used to decontaminate cages must have the prior approval of the RSO.
 - a. A description of the animal housing facilities. (i.e., a drawing showing such things as hood, doors, sink and the location of the cages).
 - b. Instruction for animal caretaker must be developed with the assistance of the RSO.
 - c. Special attention must be given to animal room security.
 - d. The amount of radioactivity should be as low as is reasonably achievable.

3. DISPOSAL

A. General Guidance

- i. All radioactivity labels must be defaced or removed from containers and packages prior to disposal in in-house waste. If waste is compacted, all labels that are visible in the compacted mass must be defaced or removed.
- ii. Remind employees that nonradioactive waste such as leftover reagents, boxes, and packing material should not be mixed with radioactive waste.
- iii. Occasionally monitor all procedures to ensure that radioactive waste is not created unnecessarily. Review all new procedures to ensure that waste is handled in a manner consistent with established procedures.
- iv. In all cases, consider the entire impact of various available disposal routes. Consider occupational and public exposure to radiation, other hazards associated with the material and routes of disposal (e.g., toxicity, carcinogenicity, pathogenicity, flammability).
- v. In New York State the Department of Environmental Conservation regulates releases to the environment and has enacted regulations on the transport of low-level radioactive waste in New York State (6 NYCRR Part 381). These regulations require that a properly executed manifest and a valid transport permit issued by Department of Environmental Conservation accompany all waste shipments.
 - Specific radioactive waste disposal procedures must be arranged with the RSO. However, these general rules apply to all users. No radioactive wastes shall be disposed of by conventional methods. This means particularly that waste may not be placed in the standard waste containers to be collected by the housekeeping personnel, and that liquid waste may not be discharged into the sewer. No radioactive waste shall be released from a laboratory area for pickup and disposal prior to deactivation of infectious agent(s).
 - The RSO arranges for disposal of radioactive wastes. On request, the RSO will collect radioactive wastes and store them until picked up by the firm licensed by New York State to receive and dispose of radioactive materials. Any questions on what is a permissible method of disposal after reviewing the appropriate regulations can be addressed by the RSO. A copy of the Record of Use form must be submitted to the RSO when disposing of wastes.
- vi. All wastes must be placed in containers approved by the RSO.
- vii. Upon placing materials in the containers, the isotope, activity, date, Chemical Form, and percent by weight of chelating agents, if any, must be entered on a card affixed to the top of the container.
- viii. Maximum radiation level at any container surface shall not exceed 200 mR/hr.
- ix. No container may contain materials (whether radioactive or not) which would create a hazard because of potential explosive or flammable properties.
- x. Solid dry waste containers must not contain any liquids.
 - Liquid Scintillation Vials must be intact with vial tops securely in place and kept separate from other waste. They may contain only H-3 and/or C-14. If you need to count other isotopes in liquid scintillation fluid, consult with the RSO.

4. EMERGENCY PROCEDURES

A. Emergency Contacts

All steps following the notification of the RSO should be taken and under RSO supervision.

Emergency Contacts:

Patrick Reardon, RSO

Office: (607) 777-3589

Email: preardon@binghamton.edu

Binghamton University Police

Campus Phone: (x911)

Non-Campus Phone: (607) 777-2222

Alternate contact designated by the RSO: Joseph Biscardi

Office: (607) 777-5799

Environmental Health and Safety

Office: (607) 777-2211

B. Spill Procedures

These procedures must be posted as required by Section 16.13 (b), New York State Sanitary Code (10 NYCRR 16). Major versus minor spills are based on the quantity (activity) of the material involved. The RSO will determine and convey the parameters to the users.

- i. Minor Spills: A spill is considered minor if:
 - a. It is confined to the immediate work area (i.e., table top or tray).
 - b. No one is contaminated.
 - c. No shielding is required to perform the experiment.
 - d. There are no gases, vapors or volatile solutions.
 - e. It is easily cleaned up by the user.
- ii. Steps to take:
 - a. NOTIFY: Notify persons in the area that a spill has occurred.
 - b. PREVENT THE SPREAD: Cover the spill with absorbent paper.
 - c. CLEAN UP: Use disposable gloves and remote handling tongs. Carefully fold the absorbent paper and pad. Insert into a plastic bag and dispose of in the radioactive waste container. Also insert into the plastic bag all other contaminated materials such as contaminated gloves.
 - d. SURVEY: With a low-range thin-window GM survey meter, check the area around the spill, hands, and clothing for contamination.
 - e. REPORT: Report incident to the RSO.
- iii. Major Spills: A spill is considered major if:
 - a. Shielding is required to perform the experiment.

- b. It is not confined to the immediate work area.
 - c. Anyone is contaminated or injured.
 - d. There are gases, vapors or volatile solution.
 - e. A fire is involved.
 - f. It is very difficult for the user to clean up. (i.e. more than three decontamination attempts).
- iv. Steps to take:
- a. CLEAR THE AREA: Notify all persons not involved in the spill to vacate the room.
 - b. PREVENT THE SPREAD: Cover the spill with absorbent pads, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spread.
 - c. SHIELD THE SOURCE: If possible, the spill should be shielded, but only if it can be done without further contamination or without significantly increasing your radiation exposure.
 - d. CLOSE THE ROOM: Leave the room and lock the door(s) to prevent entry.
 - e. CALL FOR HELP: Notify the RSO immediately.
 - f. 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.
- v. The RSO will supervise the clean-up of the spill and will complete a report. See emergency contact information in section 4(A) of this manual.

C. *Injuries to Personnel Involving Radiation Hazard*

- i. Wash minor wounds immediately under running water while spreading the edges of the gash.
- ii. Campus Phone-Dial Ext. 911 and ask for a Binghamton University New York State Police Officer to transport the injured person to the infirmary or hospital. Indicate to the Officer the amount of radioactivity and type used.
- iii. Cell Phone-Dial (607) 777-2222 and ask for a Binghamton University New York State Police Officer to transport the injured person to the infirmary or hospital. Indicate to the Officer the amount of radioactivity and type used.
- iv. Report all radiation accidents to personnel to the RSO at (607) 777-3589 as soon as possible. Complete the Accident Report form supplied to you by the RSO.
- v. Permit no person involved in a radiation injury to return to work without the approval of the RSO and of the attending physician.
- vi. Prepare a complete history of the accident for the RSO records.

D. *Fires and Other Emergencies*

- i. In case of fire pull the nearest alarm box and dial Ext. 911 on a campus phone or (607) 777-2222 on a cell phone to report the fire -- indicate the presence of radioisotopes and remain on the line until responders arrive. Do not attempt to contain the fire.
- ii. Notify the RSO as soon as safely achievable.
- iii. Following the emergency, monitor the area and determine the protective devices necessary for safe decontamination.
- iv. Decontaminate.

- v. Permit no person to resume work without approval of the RSO.
- vi. Monitor all persons involved in combating the emergency.
- vii. Prepare a complete history of the emergency for the RSO. Unless otherwise specified by the RSO, the Binghamton University New York State Police Officers and Emergency Response Team will form a perimeter cordon of the spill area to prevent access of unwanted personnel and to prevent personnel within the perimeter from leaving the area with contaminated clothing. All personnel leaving the area must be monitored and decontaminated, if necessary, by the RSO.

E. Theft or Loss of Radiation Source

Any theft or loss of any radioactive material or sources must be reported to the RSO and University Police immediately.

5. RULES OF THUMB

(From U.S. Department of Health, Education, and Welfare, Publication No. [NIH 79-18](#))

A. Beta Radiation

- i. Beta particles of at least 70 keV energy are required to penetrate the nominal protective layer of the skin (7 mg/cm² or 0.07 mm).
- ii. The average energy of a beta-ray spectrum is approximately one-third the maximum energy.
- iii. The range of beta particles in air is 12 ft/MeV. (Maximum range of ³²P beta is 1.71 MeV x 12 ft/MeV 20 ft).
- iv. The dose rate in rads per hour in a solution by a beta emitter is $1.12 EC/p$, where E is the average beta energy per disintegration in MeV, C is the concentration in μC per cm³, and p is the density of the medium in grams per cubic centimeter. The dose rate at the surface of the solution is one-half the value given by this relation. (For ³²P average energy of approximately 0.7 MeV, the dose rate from 1 Ci/cm³ (in water) is 1.48 rads/hr.).
- v. The surface dose rate through the nominal protective layer of skin (7 mg/cm²) from a uniform thin deposition of 1 Ci/cm² is about 9 rads/hr for energies above about 0.6 MeV. Note that in a thin layer, the beta dose rate exceeds the gamma dose rate, for equal energies released, by about a factor of 100.
- vi. For a point source of beta radiation (neglecting self and air absorption) of activity in millicuries (mCi), the dose rate at 1 cm in rads/hour is approximately equal to 200 x mCi. The dose rate varies only slowly with beta energy. For example, dose rate for 1 mCi ³²P at 1 cm is approximately 200 rads/hour.

B. Gamma Rays

- i. For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate (mR/hr) within 20% at 1 foot is $6 \times \text{mCi} \times E \times n$, where mCi is the number of millicuries; E, the energy in MeV; and n, the number of gammas per disintegration.
- ii. The dose rate to tissue in rads per hour in an infinite medium uniformly contaminated by a gamma emitter is $2.12 EC/p$, where C is the number of μC per cm³, E is the average gamma energy per disintegration in MeV, and p is the density of the medium. At the surface of a large body, the dose rate is about half.

C. X-Ray

- i. The exposure rate at 2 feet from diagnostic x-ray equipment operated at 100 kVp and 100 milliamperes is approximately 2.3 roentgens/second.
- ii. Exposure rate at the fluoroscopy table with tube potential at 80 kVp and tube current of 1 milliampere should not exceed 2.1 roentgens/minute.
- iii. Scattered radiation can be as penetrating as the primary beam.

D. X-Ray Diffraction

- i. The x-ray beam intensities from the primary beam can be as much as 400,000 Roentgens/min.

- ii. Scattered radiation 10 cm from the points of scatter about the x-ray tube head has been measured in the order of 150 Roentgens/hr.
- iii. The threshold dose sufficient to produce skin erythema is 300 to 400 roentgens.
- iv. The minimum cataractogenic single dose is 200 rads, while a dose of 750 rads exhibits a high incidence of cataract formation.

E. Miscellaneous

- i. The activity of any radionuclide is reduced to less than 1% after 7 half-lives.
- ii. For material with a half-life greater than six days, the change in activity in 24 hours will be less than 10%.

6. SUMMARY OF GENERAL LABORATORY REGULATIONS

- a. Smoking, eating, drinking, and the application of cosmetics in the laboratory are not permitted.
- b. Pipetting by mouth is never permitted. Use suction device such as a pipette filler.
- c. Gloves and laboratory coats should be worn when working with all liquid and solid radioisotopes.
- d. Before leaving the laboratory, remove all PPE, wash hands thoroughly, and then check for possible contamination with survey instrument.
- e. All radioactive liquid wastes are to be poured into the liquid waste container never into a laboratory sink. All solid radioactive waste and contaminated materials must be placed in the trash receptacle marked "Radioactive Waste."
- f. Report spills, wounds, or other emergencies to the RSO immediately.
- g. Maintain good housekeeping at all times in the laboratory.
- h. Store radioactive materials only in the designated storage area. Do not remove sources from the laboratory.
- i. Additional guidance on proper laboratory procedures and chemical handling is set forth in the [Laboratory Safety Manual and Chemical Hygiene Plan](#).
- j. Additional guidance on proper hazardous waste collection and storage procedures are set forth in the [Hazardous Waste Management Guide](#).

7. RESOURCES

New York State Department of health Radioactive Materials Licensing

https://www.health.ny.gov/environmental/radiological/radon/radioactive_material_licensing/

Part 16 - Ionizing Radiation (Statutory authority: Public Health Law, Section 225)

https://www.health.ny.gov/environmental/radiological/radon/radioactive_material_licensing/docs/part16.pdf

Binghamton University Environmental Health and Safety

<https://www.binghamton.edu/offices/environmental-health-safety/index.html>

Binghamton University Research Compliance-Radiation Safety

<https://www.binghamton.edu/research/compliance/radiationsafety.html>

Binghamton University New York State Police

<https://www.binghamton.edu/police/>

New York State Department of Environmental Conservation (NYSDEC) Part 380

[https://govt.westlaw.com/nycrr/Browse/Home/NewYork/NewYorkCodesRulesandRegulations?guid=le3b09be0b5a011dda0a4e17826ebc834&originationContext=documenttoc&transitionType=Default&contextData=\(sc.Default\)](https://govt.westlaw.com/nycrr/Browse/Home/NewYork/NewYorkCodesRulesandRegulations?guid=le3b09be0b5a011dda0a4e17826ebc834&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default))

ORAU Museum of Radiation and Radioactivity

<https://www.orau.org/health-physics-museum/library/index.html>

IAEA Table of Nuclides – Nuclear Structure and Decay Data

<https://www-nds.iaea.org/relnsd/vcharhtml/VChartHTML.html>

National Institutes of Health Radiation Safety Guide (NIH 79-18)

https://archive.org/stream/nationalinstitut00nati_11/nationalinstitut00nati_11_djvu.txt

APPENDIX A – PROCEDURE FOR LEAK TESTING SEALED SOURCES

The RSO appointed by the RSC is to follow the steps below to verify the safe use of sealed sources, as required by Section 16.10(a)(4), New York Sanitary Code, (10 NYCRR 16).

- 1) Make a list of all sources to be tested. This should include at least the isotope, the activity on a specified date, and the physical form.
- 2) If you will be testing high-activity sources, set out a survey meter, preferably with a speaker, so you can monitor your exposure rate.
- 3) Prepare a separate wipe sample for each source. A cotton swab, injection prep pad, filter paper, or tissue paper is suitable. Number each wipe so you will know for which source it is to be used. Samples should be taken as follows:
 - a) For small sealed sources, it is easiest to wipe the entire accessible surface area. Pay particular attention to seams and joints. However, do not wipe the port of beta applicators.
 - b) For larger sealed sources and devices (survey meter calibrator, irradiators), take the wipe near the radiation port and on the activating mechanism.
 - c) If you are testing radium sources, they should also be checked for radon leakage. This can be done by submerging the source in a vial of fine-grained charcoal or cotton for a day. Then remove the source and analyze the adsorbent sample as described below. A survey should be done to be sure the sources are adequately shielded during the leak-test period.
- 4) The samples will be analyzed as follows:
 - a) Select a suitable detector that is sufficiently sensitive to detect 0.005 microcuries. For beta sources, a proportional flow counter, liquid scintillation counter, or thin-end window GM survey meter may be appropriate. For gamma sources, a crystal with a ratemeter or scaler or a GM survey meter may be appropriate.
 - b) Assay a check source that has the same isotope as the sealed source and whose activity is certified by the supplier. If one is not available, it will be necessary to use a certified check source with a different isotope that has a similar spectrum in order to estimate the detection efficiency of the analyzer used to assay the wipe samples.
 - c) Assay the wipe sample. It must be in the same geometry relative to the detector as was the certified check source.
 - d) Calculate the estimated activity in microcuries on the wipe sample.
 - e) Continue same analysis procedure for all wipe samples.
 - f) If the wipe sample activity is 0.005 microcuries or greater, notify the RSO. The source must be withdrawn from use to be repaired or disposed of and the Health Department must be notified.
 - g) Record the wipe sample results on the list of sources, and sign and date the list.