

**STATE UNIVERSITY OF NEW YORK
AT BINGHAMTON
SCHOOL OF PHARMACY AND PHARMACEUTICAL SCIENCES**

**RADIOACTIVE MATERIALS AND X-RAY EQUIPMENT
SAFETY MANUAL**

**BRET PEARSALL, RADIATION SAFETY OFFICER
SCHOOL OF PHARMACY AND PHARMACEUTICAL SCIENCES
ENVIRONMENTAL HEALTH AND SAFETY OFFICE
ROOM G-44
PHONE: OFFICE: (607) 777-6835**

NYS DOH License #5902

Updated 03/06/2019nl

TABLE OF CONTENTS

1.	REGULATIONS AND PROCEDURES	3
A.	Radiation Safety Committee	3
B.	Training	4
C.	Records for Training Documentation	5
D.	RSO Duties, Responsibilities, Authority	5
2.	ACQUISITION, STORAGE AND CONTROL	7
A.	Procurement	7
B.	Receipt	7
C.	Storage	7
D.	Use	7
E.	Steps to Obtain Approval	8
F.	Record of Use	8
G.	Enforcement Procedure	8
H.	Annual Audit and Program Review	9
I.	Radiation Survey	10
J.	Decontamination	11
K.	General	12
L.	Personnel Monitoring Program	13
M.	Occupational Dose Limits	14
3.	DISPOSAL	15
A.	General	15
B.	Liquid Scintillation Vials	15
4.	EMERGENCY PROCEDURES	15
A.	Emergency Contacts	15
B.	Spill Procedures	16
C.	Injuries to Personnel Involving Radiation Hazard	17
D.	Fires and Other Emergencies	18
E.	Theft or Loss of Radiation Source	18
5.	RULES OF THUMB	18
A.	Beta Radiation	19
B.	Gamma Rays	19
C.	X-Ray	19
D.	X-Ray Diffraction	20
E.	Miscellaneous	20
6.	SUMMARY OF GENERAL LABORATORY REGULATIONS	20
7.	RESOURCES	21
	APPENDIX A	22

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, School of Pharmacy and Pharmaceutical Sciences (SOPPS) in the ordering, receipt, storage, use, and disposal of radioactive materials. This manual supercedes all other university documents related to radiation safety. A notice of the existence of the SOPPS Safety Manual will be announced via the online campus wide daily news feed at the beginning of each Fall semester. A copy of the SOPPS 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

The Radiation Safety Committee operates under New York State Department of Health Radioactive Materials Licenses #588 and #5902. Faculty or staff wishing to use radioactive materials must apply to the Radiation Safety Committee for permission. Upon approval of an application, the applicant will be informed as to maximum limits. A maximum limit for stock pulse stored as waste will be set by the committee.

Responsibilities

2. 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.
3. 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.
4. 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.
5. 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.
6. Be responsible for monitoring the institution's program to maintain individual and collective doses as low as reasonably achievable.
7. Review semi-annually, with the assistance of the Radiation Safety Officer (RSO), occupational radiation exposure records of all personnel working with radioactive materials.
8. 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 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 Committee 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 Radiation Safety Committee 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 Committee's membership, and must include the RSO and the management representative.
- xvi. Committee 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 Committee 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 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. RSO: Duties, Responsibilities and Authority

The Vice President for Operations makes the appointment of the RSO. The RSO is responsible 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 Radiation Safety Committee.

- 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 hon 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 Radiation Safety Committee 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 Bret Pearsall, RSO in the Radioactive Materials Storage Facility, Room G-11 of the SOPPS building at 96 Corliss Ave, Johnson City, NY 13790.
- 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

All packages labeled "Radioactive Material" received at SOPPS by mail or by personal carrier will be delivered to the RSO, Room G-11 of the SOPPS building at 96 Corliss Ave, Johnson City, NY 13790. The RSO will receive and record all radioactive materials delivered to State University of New York at Binghamton SOPPS 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, e.g., gas chromatographs and x-ray equipment.

C. 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.

D. Use

All use of radioactive materials for research or instructional purposes by faculty, staff, or students must be cleared with the Radiation Safety Committee. Prior to starting any experiments with radioactive isotopes, the faculty and staff must apply to the Radiation Safety Committee for a license. 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 update their 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 makes a determination 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.

E. 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) 777-4664. You may also contact the RSO at (607) 777-6835. For specific questions regarding your use and research.
- ii. The Radiation Safety Committee reviews the proposal.
- iii. The applicant is notified by the RSO 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 Committee are to go through the RSO.
- vi. If a film badge is required, it will be provided by the RSO.

F. 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.

G. 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 Radiation Safety Committee and the Assistant Vice President for Research Compliance.
- c. The Radiation Safety Committee 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 Radiation Safety Committee.
- f. The Radiation Safety Committee 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).

H. 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

I. 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).

J. 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.

K. 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 maintains 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.

L. Personnel Monitoring

- a. Adults likely to receive, in one year from sources external to the body, a dose in excess of 10 percent of the limit for occupational dose limit will be issued and MUST use an individual monitoring device.
- b. Minors and declared pregnant women likely to receive, in one year from sources external to the body, a dose in excess of 10 percent of limit for occupational dose limit will be issued and MUST use an individual monitoring device.

- c. During initial training and during annual refresher training the RSO will review the work environment to determine if a monitoring device is required.

M. 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.

3. DISPOSAL

A. General

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).

- i. 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 the RSO. A copy of the Record of Use form must be submitted to the RSO when disposing of wastes.
- ii. All wastes must be placed in containers approved by the RSO.
- iii. 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.
- iv. Maximum radiation level at any container surface shall not exceed 200 mR/hr.
- v. No container may contain materials (whether radioactive or not) which would create a hazard because of potential explosive or flammable properties.
- vi. Solid dry waste containers must not contain any liquids.

B. Liquid Scintillation Vials

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:

RSO

Office: (607) 777-6835

Cell: (607) 343-1701

Binghamton University Police

Campus Phone: (x911)

Non-Campus Phone: (607) 777-2222

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 (<100 microcuries): 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 (>100 microcuries): 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.

The RSO will supervise the clean-up of the spill and will complete a report.

RSO: Bret Pearsall

Office Phone: (607) 777-6835

Cell Phone: (607) 343-1701

Alternate contact designated by the RSO: Lynda Ruffini

Office Phone: (607) 777-5810

Cell Phone: (607) 351-9057

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) 777-6835 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 at (607) 777-6835 or at (607) 343-1701
- 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 immediately at (607) 777-6835 or at (607) 343-1701.

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 $\mu\text{Ci/cm}^3$, 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 $200 \times \text{mCi}$. 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 $\mu\text{Ci/cm}^3$, 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

Smoking, eating, drinking, and the application of cosmetics in the laboratory are not permitted.

Pipetting by mouth is never permitted. Use suction device such as a pipette filler.

Gloves and laboratory coats should be worn when working with all liquid and solid radioisotopes.

Before leaving the laboratory, remove all PPE, wash hands thoroughly, and then check for possible contamination with survey instrument.

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 should be placed in the trash receptacle marked "Radioactive Waste."

Report spills, wounds, or other emergencies to the RSO immediately.

Maintain good housekeeping at all times in the laboratory.

Store radioactive materials only in the designated storage area. Do not remove sources from the laboratory.

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

[U.S. DHHS Radiation Emergency Medical Management](#)

Binghamton University Research Compliance-Radiation Safety
<https://www.binghamton.edu/research/compliance/radiationsafety.html>

Binghamton University Emergency Management
<https://www.binghamton.edu/emergency/>

Binghamton University New York State Police
<https://www.binghamton.edu/police/>

APPENDIX A

Concentrations in Air and Water Above Natural Background

This document can also be viewed on the United States Nuclear Regulatory Commission website at the link below. You can find a complete list of radionuclides [HERE](https://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-appb.html).

<https://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-appb.html>

Appendix B to Part 20—Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

Introduction

For each radionuclide Table 1 indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times of less than 10 days for D, for W from 10 to 100 days, and for Y greater than 100 days. The class (D, W, or Y) given in the column headed "Class" applies only to the inhalation ALIs and DACs given in Table 1, columns 2 and 3. Table 2 provides concentration limits for airborne and liquid effluents released to the general environment. Table 3 provides concentration limits for discharges to sanitary sewer systems.

Notation

The values in Tables 1, 2, and 3 are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of 6×10^{-2} or 0.06, 6E+2 represents 6×10^2 or 600, and 6E+0 represents 6×10^0 or 6.

Table 1 "Occupational Values"

Note that the columns in Table 1, of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of a given radionuclide by "Reference Man" which would result in either (1) a committed effective dose equivalent of 5 rems (stochastic ALI) or (2) a committed dose equivalent of 50 rems to an organ or tissue (non-stochastic ALI).

The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 5 rems. The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T . This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in § 20.1003. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of $w_T=0.06$ is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other

remaining tissues may be disregarded. The following parts of the GI tract—stomach, small intestine, upper large intestine, and lower large intestine—are to be treated as four separate organs.

Note that the dose equivalents for extremities (hands and forearms, feet and lower legs), skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an ALI is defined by the stochastic dose limit, this value alone, is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. (Abbreviated organ or tissue designations are used: LLI wall = lower large intestine wall; St. wall = stomach wall; Blad wall = bladder wall; and Bone surf = bone surface.)

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 50-rem dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose to that organ (not the effective dose). For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the non-stochastic

ALIs (ALIs) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity (i.e., $\sum (\text{intake (in } \mu\text{Ci) of each radionuclide} / \text{ALIs}) < 1.0$). If there is an external deep dose equivalent contribution of H_d then this sum must be less than $1 - (H_d/50)$ instead of being < 1.0 .

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by: $\text{DAC} = \text{ALI} / (\text{in } \mu\text{Ci}) / (2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [\text{ALI} / 2.4 \times 10^9] \mu\text{Ci/ml}$, where $2 \times 10^4 \text{ ml}$ is the volume of air breathed per minute at work by "Reference Man" under working conditions of "light work."

The DAC values relate to one of two modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. Derived air concentrations based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values relate to exposure to the single radionuclide named, but also include contributions from the in-growth of any daughter radionuclide produced in the body by the decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The value of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external radiation

(see § 20.1202). When an individual is exposed to radioactive materials which fall under several of the translocation classifications (i.e., Class D, Class W, or Class Y) of the same radionuclide, the exposure may be evaluated as if it were a mixture of different radionuclides. It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radioisotopes. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table 2 "Effluent Concentrations"

The columns in Table 2 of this appendix captioned "Effluents," "Air," and "Water," are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of § 20.1302. The concentration values given in Columns 1 and 2 of Table 2 are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem (50 millirem or 0.5 millisieverts).

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table 2. For this reason, the DAC and airborne effluent limits are not always proportional as was the case in appendix B to §§ 20.1-20.601.

The air concentration values listed in Table 2, Column 1, were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4×10^9 ml, relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 5-rem annual occupational dose limit to the 0.1-rem limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values (derived for adults) so that they are applicable to other age groups. For those radionuclides for which submersion (external dose) is limiting, the occupational DAC in Table 1, Column 3, was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^7 . The factor of 7.3×10^7 (ml) includes the following components: the factors of 50 and 2 described above and a factor of 7.3×10^5 (ml) which is the annual water intake of "Reference Man."

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings (including occupational inhalation ALIs and DACs, air and water effluent concentrations and sewerage) require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionuclides cannot be definitely excluded

either from knowledge of the radionuclide composition of the source or from actual measurements.

Table 3 "Releases to Sewers"

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in § 20.2003. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6 (ml). The factor of 7.3×10^6 (ml) is composed of a factor of 7.3×10^5 (ml), the annual water intake by "Reference Man," and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 0.5 rem.

List of Elements

Name	Atomic	
	Symbol	No.
Actinium	Ac	89
Aluminium	Al	13
Americium	Am	95
Antimony	Sb	51
Argon	Ar	18
Arsenic	As	33
Astatine	At	85
Barium	Ba	56
Berkelium	Bk	97
Beryllium	Be	4
Bismuth	Bi	83
Bromine	Br	35
Cadmium	Cd	48
Calcium	Ca	20
Californium	Cf	98
Carbon	C	6
Cerium	Ce	58
Cesium	Cs	55

Chlorine	Cl	17
Chromium	Cr	24
Cobalt	Co	27
Copper	Cu	29
Curium	Cm	96
Dysprosium	Dy	66
Einsteinium	Es	99
Erbium	Er	68
Europium	Eu	63
Femium	Fm	100
Fluorine	F	9
Francium	Fr	87
Gadolinium	Gd	64
Gallium	Ga	31
Germanium	Ge	32
Gold	Au	79
Hafniim	Hf	72
Holmium	Ho	67
Hydrogen	H	1
Indium	In	49
Iodine	I	53
Iridium	Ir	77
Iron	Fe	26
Krypton	Kr	36
Lanthanum	La	57
Lead	Pb	82
Lutetium	Lu	71

Magnesium	Mg	12
Manganese	Mn	25
Mendelevium	Md	101
Mercury	Hg	80
Molybdenum	Mo	42
Neodymium	Nd	60
Neptunium	Np	93
Nickel	Ni	28
Niobium	Nb	41
Nitrogen	N	7
Osmium	Os	76
Oxygen	O	8
Palladium	Pd	46
Phosphorus	P	15
Platinum	Pt	78
Plutonium	Pu	94
Polonium	Po	84
Potassium	K	19
Praseodymium	Pr	59
Promethium	Pm	61
Protactinium	Pa	91
Radium	Ra	88
Radon	Rn	86
Rhenium	Re	75
Rhodium	Rh	45
Rubidium	Rb	37
Ruthenium	Ru	44

Samarium	Sm	62
Scandium	Sc	21
Selenium	Se	34
Silicon	Si	14
Silver	Ag	47
Sodium	Na	11
Strontium	Sr	38
Sulfur	S	16
Tantalum	Ta	73
Technetium	Tc	43
Tellurium	Te	52
Terbium	Tb	65
Thallium	Tl	81
Thorium	Th	90
Thulium	Tm	69
Tin	Sn	50
Titanium	Ti	22
Tungsten	W	74
Uranium	U	92
Vanadium	V	23
Xenon	Xe	54
Ytterbium	Yb	70
Yttrium	Y	39
Zinc	Zn	30
Zirconium	Zr	40

[56 FR 23409, May 21, 1991; 56 FR 61352, Dec. 3, 1991, as amended at 57 FR 57879, Dec. 8, 1992. Redesignated at 58 FR 67659, Dec. 22, 1993; 71 FR 15007, Mar. 27, 2006; 72 FR 55922, Oct. 1, 2007; 75 FR 73938, Nov. 30, 2010]