Department of
Environmental
Health & Radiation
Safety

University Radiation Safety Manual

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Drexel University Department of Environmental Health & Radiation Safety Contact Information

Drexel University Radiation Safety Officer

Jonathan M. Chase, M.S.

Administrative Section

400 N. 31st St.
Philadelphia, PA 19104

Office Telephone – (215) 895-5919

Radiation Safety Officer – (215) 669-6122

Technical Section

New College Building, Room 12135 / Mail Stop 106
245 N. 15th St.
Philadelphia, PA 19102

Office Telephone – (267) 359-2606

Radiation Safety Technician – (215) 203-6733

Email

radiationsafety@drexel.edu

ehrs@drexel.edu

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Section I – Radiation Safety Program Administrative Structure

I. a. Scope and Authority

Scope

This manual establishes the policies and procedures for controlling the receipt, transfer, use, possession, and disposal of sources of ionizing radiation. Use of the term *radiation* in this manual refers to ionizing radiation, including alpha particles, beta particles, X-rays, gamma rays, internal conversion electrons and auger electrons emitted from radioactive materials, X-rays, high energy electron beams, and other accelerated charged particle beams created by electrical equipment. Non-ionizing radiation, such as lasers, ultraviolet radiation, and microwaves are beyond the scope of this manual.

The policies and procedures in this manual apply to Drexel University, Drexel University College of Medicine and all other affiliated organizations for which the Radiation Safety Officer has been directed to take responsibility by University management.

Supplementary radiation safety procedures for specialized practices (e.g., nuclear cardiology, eye plaque brachytherapy, monoclonal antibody therapy) have also been established. In general, the supplementary procedures are in addition to the policies and procedures in this manual. In cases where the supplementary radiation safety procedures conflict with policies and procedures contained in the general section, the specific policies and procedures supersede and take priority over general policies and procedures.

Regulatory Authority

Sources of ionizing radiation are regulated by both state and federal governments. On March 31, 2008, the Commonwealth of Pennsylvania became an “Agreement State” by entering into an agreement with the U.S. Nuclear Regulatory Commission (NRC). As a result, the Pennsylvania Department of Environmental Protection Bureau of Radiological Protection (PaDEP) has jurisdiction over the use of sources of ionizing radiation used at the University. These regulations can be found in Title 25 of the Pennsylvania Code. As a means of maintaining compatibility, the Commonwealth’s regulations incorporate by reference much of the NRC regulations.

The receipt, possession, use, transfer, and disposal of radioactive materials at the University are controlled by licenses issued by the NRC and PaDEP. The University is restricted to radioactive materials listed on specific licenses issued to the University, allowed by general licenses issued in the regulations, or exempt from regulations.

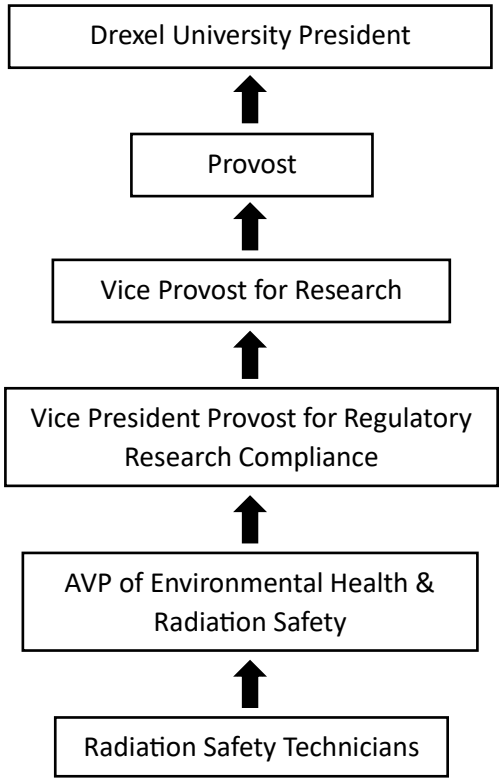
Radiation-producing equipment is controlled by registration with the PaDEP. This equipment includes analytical X-ray equipment, radiographic and fluoroscopic units, electron microscopes, and electron beam welders.

Section I – Radiation Safety Program Administrative Structure

I. b. Organizational Structure

The Provost is responsible for the oversight of the Radiation Safety Program and has the ultimate responsibility for the use of sources of ionizing radiation at the University. As indicated in the organizational chart below, the Provost reports directly to the President of the University.

The Director of Environmental Health & Radiation Safety / Radiation Safety Officer reports to the Vice Provost for Regulatory Research Compliance, who, in turn, reports directly to the Vice Provost for Research. Radiation Safety Technicians report to the Director of Environmental Health & Radiation Safety.



The Vice Provost for Regulatory Research Compliance has appointed a Radiation Safety Committee with the charge of establishing and maintaining the Radiation Safety Program.

Section I – Radiation Safety Program Administrative Structure

I. c. Radiation Safety Committee

The Vice Provost for Regulatory Research Compliance appoints the chair and members of the Radiation Safety Committee. The Committee is composed of faculty members that represent departments using radiation sources as well as other individuals representing key functional areas of the institution (e.g., Environmental Health & Radiation Safety). The Radiation Safety Officer is a permanent member of the Committee and the Vice Provost for Regulatory Research Compliance is a member by right of office, representing University Administration. Alternate members may be appointed in the case of absence of principal Committee members. Alternate members are counted towards the quorum and are permitted to vote on matters before the Committee.

The responsibilities of the Radiation Safety Committee are to:

- Ensure that radiation sources are used safely.
- Ensure that radiation sources are used in compliance with federal and state regulations.
- Ensure that the use of radiation sources is consistent with the principle of maintaining radiation exposures as low as reasonably achievable (ALARA).
- Identify program deficiencies and suggest solutions.

To meet these responsibilities, the Radiation Safety Committee will:

- Meet as often as necessary (nominally once each calendar quarter) to conduct its business. To establish a quorum, one-half of the Committee's membership, including the RSO, must be present. The Committee may conduct business between convened meetings through e-mail, teleconference, or other means.
- Be familiar with all pertinent regulations, license applications, licenses, and amendments.
- Review the training and experience of the proposed authorized users and the Radiation Safety Officer to determine that their qualifications are sufficient to enable the individuals to perform their duties safely and are in accordance with the regulations and the license.
- Review on the basis of safety and approve or deny requests for authorization to use radioactive material consistent with regulations, licenses and the ALARA philosophy.
- Prescribe special conditions of approval to use radioactive material such as requirements for bioassays, medical examinations of users, and special monitoring procedures.
- Review the Radiation Safety Officer's summary of occupational radiation exposures of personnel, giving attention to individuals or groups of workers whose occupational exposures appear unusual or excessive.
- Establish a program to provide radiation safety instructions to all persons whose duties may result in an occupational dose exceeding 100 millirem (1 millisievert) in a year (e.g., security, housekeeping, and physical plant employees).
- Review and approve of program and procedural changes prior to their implementation.
- Implement, through the Radiation Safety Officer, the program and procedural changes.
- Review at least annually the RSO's summary report of the entire radiation safety program to determine that all activities are being conducted safely, in accordance with regulations and the conditions of the licenses, and consistent with the ALARA program and philosophy. The review will include an examination of records, reports from the RSO, results of regulatory agency inspections, written safety procedures, the impact of procedural or program changes, and adequacy of the management control system.

Section I – Radiation Safety Program Administrative Structure

- Determine the cause of noncompliance or deficiencies in the radiation safety program and take corrective actions that include actions to prevent recurrence.
- Maintain written minutes of Committee meetings, including members in attendance and absent, discussions, actions, recommendations, decisions, and results of votes taken.

I. d. Radiation Safety Officer

The appointed Radiation Safety Officer (RSO) is responsible for ensuring the safe use of sources of radiation. The RSO is responsible for managing the Radiation Safety Program; identifying radiation safety problems; initiating, recommending, or providing corrective actions; verifying implementation of corrective actions; and ensuring compliance with regulations. The RSO assists the Radiation Safety Committee to meet its charge and implements the policies and procedures established by the Committee.

Responsibilities of the Radiation Safety Officer:

- General surveillance of all radiation safety activities, including investigations of overexposures, accidents, spills, losses, thefts, unauthorized receipts, uses, transfers, disposals, medical events, and other deviations from approved radiation safety practices and implementation of corrective actions;
- Authorizing the purchase of radioactive material; receiving, surveying, and distributing radioactive material packages; and keeping an inventory record of radioactive material;
- Evaluating equipment, physical facilities, operational techniques and procedures;
- Assigning and evaluating personnel monitoring equipment, establishing requirements for bioassay and special monitoring procedures, and keeping records of internal and external personnel exposure;
- Assuring that personnel who work in, or visit areas where radioactive materials are used or stored, receive appropriate training;
- Overseeing disposal of radioactive waste and maintaining required disposal records;
- Providing advice and supervision for decontamination;
- Preparing reports on the radiation safety program and presenting the reports to the Radiation Safety Committee;
- Actively participating in the Radiation Safety Committee and subcommittees as a member and executive secretary;
- Maintaining federal and state licensures and registrations;
- Reviewing state and federal rulemaking and implementing changes in the radiation safety program to comply as necessary;
- Maintaining records as required by local, state, and federal regulation;
- Developing and implementing emergency plans, instructions, and drills for University staff and local police and firefighting agencies.

The RSO has been delegated the authority necessary to meet those responsibilities including the authority to suspend operations which are deemed to be unsafe or otherwise in noncompliance with licensure and/or Drexel University policy or regulations.

Section I – Radiation Safety Program Administrative Structure

I. e. Environmental Health & Radiation Safety Office
The Radiation Safety Officer is assisted by a support staff to which specific duties may be delegated.

I. f. Authorized Users
The Radiation Safety Committee authorizes specific individuals at the University to use sources of ionizing radiation. These individuals are designated as authorized users. Authorized users are responsible for conducting their activities as authorized by the Radiation Safety Committee and in accordance with the policies and procedures established by the Committee.

I. g. Supervised Users
Individuals not specifically authorized by the Radiation Safety Committee may work with sources of radiation under the supervision of an authorized user. Supervised users may include research assistants, laboratory technicians, graduate students, etc.

Section II – General Radiation Safety Policies and Procedures

II. a. Authorization Process

The Radiation Safety Committee reviews the training and experience of proposed authorized users to determine that their qualifications are sufficient for the individuals to perform their duties safely and in accordance with the regulations and the license. The Radiation Safety Committee also reviews on the basis of safety and approves or denies, consistent with the limitations of the regulations, the license, and the ALARA philosophy, all requests for authorization to use sources of radiation at the University.

Applying to Become an Authorized User

All potential authorized users must complete an application that includes their training and experience and the proposed uses of radioactive materials. The completed application is to be submitted to the RSO who pre-reviews the proposed authorized users training and experience with radioactive material. The RSO may conduct an interview with new authorized users to discuss the University's radiation safety program.

The application is reviewed and approved or disapproved by the Radiation Safety Committee. The criteria for granting approval will be based on the following schedule of training and experience.

Unless there are compelling reasons otherwise, the Radiation Safety Committee will only approve faculty members as authorized users. At a minimum, an applicant must have the following education, training and experience:

- A college degree in physical or biological sciences.
- A minimum of 40 hours formal classroom and/or supervised on-the-job training in:
    - The characteristics of ionizing radiation
    - Radiation dose and quantities
    - Radiation detection instrumentation
    - Biological hazards of exposures to radiation appropriate to the types, quantities and forms of radioactive material to be used.

An authorized user must have previous experience working with radioactive materials which pose similar radiological protection problems or must gain experience by performing:

- A dry run of proposed procedure under the review of the Radiation Safety Office.
- A limited activity run of the proposed procedure.
- The procedure under the supervision of an authorized user which has approval to perform the same procedures.

The Radiation Safety Officer / Committee will determine which is most appropriate.

An individual does not need previous experience working with similar radioactive material to work with radioactive materials exempt from licensing, radioimmunoassay kits, or generally licensed radioactive material.

Clinical authorized users must meet the training and experience requirements provided in applicable regulations. Clinical authorized users are specifically listed on the institution's medical use license for the type of clinical activity performed.

Section II – General Radiation Safety Policies and Procedures

Applying for Authorized Uses

Applications for proposed uses of radioactive material must be submitted to the Radiation Safety Officer for initial review. The Radiation Safety Officer conducts a review of the proposed use, interviews the user, and examines the facility. Specific handling procedures are addressed to reduce risks of contamination and generation of airborne radioactive material; reduce radiation levels; ensure proper disposal of radioactive waste; and general radiation safety procedures.

The facilities and equipment are reviewed for adequacy. Generally, laboratories must have a sink, telephone, doors which lock, workspace suitable for the proposed radioactive work, and access to radiation detection equipment. The type, quantity, and accessibility of radiation detection equipment depends on the type and activity of radioactive material being used.

> For example, a radiation survey meter is not required for a laboratory handing tritium or RIA kits, but a survey meter is required for laboratories working with millicurie quantities of ^{32}P. Local or area shielding will be evaluated to assure that dose rates in unrestricted areas are less than 2 millirem/hour and that an individual in unrestricted areas would not receive an annual dose in excess of 100 millirem.

II. b. Tentative Approvals

Tentative approval for proposed uses may be granted by the Radiation Safety Officer with concurrence by the Chair of the Radiation Safety Committee. To be considered for tentative approval, proposed uses must meet the following conditions:

- The individual has already been approved as an authorized user for other materials/uses,
- The proposed use is similar to other approved uses at the institution,
- The proposed use is an in vitro experiment, and
- The use does not involve activities greater than 1 millicurie (for requests to increase the possession limit, the increase may not exceed 1 millicurie).

In general, tentative approvals are granted to:

- Change chemical forms,
- Allow one-time-only procedures,
- Add an isotope, or
- Increase the possession limit.

Tentative approvals are temporary, expiring at the time of the next Radiation Safety Committee meeting, unless approved by the full Committee.

Section II – General Radiation Safety Policies and Procedures

II. c. Training

Each new supervised user is to receive an orientation on radiation safety practices before commencing work with sources of radiation. The Office of Environmental Health & Radiation provides various training resources including a Radiation Safety Short Course offered several times a year. Also available are specialized orientations to meet the needs of small groups of individuals. To assure the training goals, the following procedures will be followed:

Supervised Users

The Authorized User is responsible for providing appropriate laboratory specific training to supervised users prior to working with or around sources of licensed material. At a minimum, the content of this training includes:

- Applicable regulations and authorization conditions.
- Areas where radioactive materials are used or stored.
- Need to keep sources of radiation secure from unauthorized access.
- Potential hazards associated with radioactive material in each area where the supervised user will work and appropriate precautions to minimize these hazards.
- Appropriate radiation safety procedures and documentation.
- Laboratory work rules.
- Workers' obligation to report unsafe conditions to the Radiation Safety Officer.
- Appropriate responses to emergencies or unsafe conditions.
- Worker's rights to be informed of occupational radiation exposure and bioassay results.
- Locations where notices, regulations, authorizations, and authorization conditions are posted or available.
- If applicable, radiation monitoring and bioassay requirements.
- If applicable, radiation-producing device operating and emergency procedures.

In addition to the initial laboratory specific training provided by the authorized user, each radiation worker that does not have documented previous training and experience using radioactive materials must attend the Radiation Safety Short Course prior to beginning work with radioactive materials. Topics covered in the Radiation Safety Short Course include but are not limited to:

- Radiation and radioactivity
- Biological effects
- Dose limits
- ALARA
- Radiation protection
- Radiation detection
- Personnel monitoring
- Federal regulations
- Institutional controls
- General laboratory radiation safety procedures
- Posting and labeling
- Radiological contamination

Section II – General Radiation Safety Policies and Procedures

- Good laboratory practices
- Characteristics of commonly used isotopes
- Radiation accidents and emergencies
- Waste disposal
- Personal protective equipment

Attendees must demonstrate basic comprehension of the material by scoring at least 70% on an administered examination.

Ancillary Personnel

Radiation safety orientations will be provided for Maintenance, Security, Environmental Services and other ancillary staff who may have activities involving radioactive materials. At a minimum, the ancillary personnel orientation includes:

- Warning signs and restrictions for entering posted areas.
- Precautions to be followed when entering labeled facilities.
- Requirements for security of radioactive material.
- Radiation Safety Office contact information.

Other instruction will be based on the specific needs of the staff receiving the training.

Refresher training will be offered by the Radiation Safety Officer as needed and at least annually. The success of training is assessed during the audits performed by the Radiation Safety Officer.

Clinical Personnel

Personnel working with radiation sources used for medical purposes will receive training specific to their work.

II. d. External Radiation Dosimetry Program

Monitoring radiation exposure is a principal element of any radiation protection program. A well-functioning dosimetry program is essential for safe operation and for compliance with applicable Federal and Pennsylvania regulations.

Personal radiation monitoring will be provided to individuals that require monitoring based on federal and Pennsylvania regulations. These individuals include:

- Adults who are likely to receive an external radiation dose more than 10 percent of the annual dose limit (whole body doses more than 500 millirem in a year).
- Minors who are likely to receive an external dose of more than 100 millirem in a year.
- Declared pregnant individuals who are likely to receive an external dose of 100 millirem during gestation.
- Individuals entering a high or very high radiation area.
- Individuals holding film or patients during X-ray exposures.

Monitoring is also provided at the discretion of the Radiation Safety Officer for individuals who may receive a measurable external radiation exposure, but who are unlikely to receive a dose which requires monitoring based on the federal and state regulations.

It is recognized that a great deal of judgement is required to place an individual in the appropriate group and to apply a specific method of monitoring. These decisions are made by the Radiation Safety Officer based on the following criteria:

- Exposure history
- Work habits
- Nature of the work
- Quantity of radioactive materials
- Nature of the radiation
- Other relevant parameters such as the results of temporary monitoring

In general, individuals handling greater than 1 millicurie of gamma emitting or high-energy beta emitting radionuclides are monitored.

The Radiation Safety Officer reviews exposures on a regular basis. Subsequently, high or unusual exposures are reported to the Radiation Safety Committee.

External dosimeters will be provided to individuals who require monitoring and will be exchanged monthly. Dosimeters provided to discretionarily monitored individuals may be exchanged on a less frequent schedule (e.g., bi-monthly, or quarterly). All monitored individuals are expected to return their monitoring device during the scheduled exchange period. Failure to return monitoring devices during the exchange period may result in radiation utilization privileges being suspended. The Office of Environmental Health & Radiation Safety reserves the right to recoup the replacement costs of lost or damaged monitoring devices from the monitored individual's department should there become excessive (e.g., >5%).

Section II – General Radiation Safety Policies and Procedures

Use of Dosimeters

The proper use and care of dosimeters is necessary to assure that the radiation exposure received by the radiation worker is measured by the dosimeter.

- All individuals requiring monitoring need to complete the radiation worker registration form.
- The Radiation Safety Office will seek prior exposure history from prior employers for everyone for whom monitoring is required.
- Each individual receiving a dosimeter will also receive instructions as to the care and use of dosimeters.
- New employees which require monitoring must be issued dosimeter(s) before initiating work with radiation sources.
- A temporary monitor may be issued until the beginning of the next exchange period.
- The wearer of the monitoring device is responsible for the care of such devices and must assure that it is used correctly and that it is not damaged or lost.
- Whole body dosimeters should be worn on the torso between the hips and neck at the location most likely to be exposed to radiation. Ring dosimeters should be worn on the finger having the closest approach to the radiation source. The ring should be turned such that the active element (under the ID label) is closest to the radiation source.
- Individuals issued a dosimeter are to wear it while working with radiation sources.
- Individuals must never purposely expose their dosimeter to radiation for any reason. If it is desired to run a test on a dosimeter, the Office of Environmental Health & Radiation Safety can issue a test dosimeter.
- The RSO will review exposure reports and submit a summary report to the Radiation Safety Committee.
- All exposure reports are routinely sent to department or lab supervisors who in turn should make them available to the employees.
- Employees monitored at another institution must inform RSO so that the radiation exposure can be totaled to assure that the annual exposure limits are not exceeded.
- Follow these instructions for the care, use, and exchange of dosimeters:
    - Wear the dosimeter only when working at the University.
    - Do not wear a dosimeter while being exposed to radiation for personal medical reasons.
    - Do not take dosimeters home; leave the dosimeter in an area at the work site where it will not be exposed to any type of radiation when you are not wearing it.
    - Wear the dosimeter in the workplace until the beginning of the next exchange period.
    - Return an old dosimeter immediately to the collection point in your department.
    - If there is not a new dosimeter at the collection point, contact Environmental Health & Radiation Safety immediately and continue to wear the old badge.
    - If a film dosimeter is issued, the film packet is to be placed in the plastic holder. Readings are invalid for film packets exposed outside of the holder.
    - Report any damage or loss of a dosimeter immediately to the Radiation Safety Officer for replacement. Temporary dosimeters will be issued in case of loss or damage.
    - Wear the dosimeter so that the label is pointing away from your body.
    - Do not tear, wet, or write on the dosimeter.
    - Do not store dosimeters near heated areas (do not leave near radiators, heaters, etc.) or in high humidity areas.

- Do not, at any time, let anyone else wear the dosimeter assigned to you.

Any tampering with a dosimeter (one's own or someone else's) will not be tolerated. This will result in immediate disciplinary action in accordance with the University's disciplinary policy.

II. e. Internal Radiation Dosimetry Program

Internal radiation exposure results from the ingestion, absorption, inhalation, or injection of radioactive materials into the body. Small quantities of radioactive materials, which present an insignificant external hazard, can result in appreciable exposure when taken into the body. Once inside the body, the radioactive material continues to irradiate the body until it has either decayed or been excreted. The rate of decay of the radioactive material varies with the isotope's physical half-life and can be anywhere from a few seconds to several thousand years. In general, the rate of elimination from the body can be expressed as the biological half-life. The elimination rate of the material depends on a number of different factors (i.e., chemical constituents) and can occur over a period of a few days or up to many years.

The Office of Environmental Health & Radiation Safety primarily performs two types of bioassays to monitor potential ingestion, inhalation, or absorption of radioactivity into the body. These tests are analysis of urine specimens and in-vivo thyroid counting. Normally an individual is requested for such bioassays only if they conduct certain types of experiments or procedures with volatile radionuclides. Radiation workers are required to participate in the bioassay program after working with radioactive material listed in the table below:

Isotope	Form	Activity (mCi)
I-125, I-131	Unbound	1
	Bound to a non-volatile agent	10
H-3	Any compound	40
C-14	Any compound	10

- Bioassays for other radionuclides in volatile form are specified in specific conditions of authorization to use the material if it is anticipated that a potential intake in excess of 10% of the Annual Limit of Intake (ALI) for that radionuclide may occur.
- Bioassay, if needed, should be performed within 3 days of the use of radioiodines. Bioassays for intake of I-131 and I-125 are performed by in vivo thyroid counting.
- Bioassay, if needed, should be performed within 1 week of the use of tritium. Bioassay for intake of tritium is performed by radioanalysis of a urine sample.
- Bioassays can also be required if the RSO has reason to suspect that an individual had an uptake of radioactivity.

II. f. ALARA Policy

ALARA is an acronym for As Low As Reasonably Achievable and is a program to maintain radiation exposures as far below the regulatory limits as can be reasonably attained taking into account social and economic considerations. ALARA is meant to strike a balance between the costs of radiation protection, the health benefit derived from that protection and the benefit to society resulting from the use of ionizing radiation.

The University is committed to an effective radiation protection program to eliminate unnecessary exposures to radiation and to reduce all exposures to levels that are ALARA.

ALARA is instilled in all operations utilizing ionizing radiation at the University. ALARA applies to faculty, staff, students and visitors to the University and the general public. It is implemented by the comprehensive radiation protection program described in this manual and is a consideration in the deliberations of the Radiation Safety Committee.

ALARA is the responsibility of all persons involved in the use of radiation at the University. The Office of Environmental Health & Radiation Safety promotes ALARA and will assist in the practice ALARA at every available opportunity. The Radiation Safety Officer has authority to ensure adherence to ALARA principles and is supported by the University in instances where this authority must be asserted.

Standards for achievement of ALARA goals are given in the table below. The table provides levels at which prescribed actions are to be taken by the Office of Environmental Health & Radiation Safety. If a measurement point is below Level I for a calendar quarter, no action is required. Should the value be between Level I and Level II, the RSO will notify the involved individual(s) and review the circumstances. The RSO may investigate and/or take action to reduce the exposure. If Levell II is exceeded, the RSO will investigate and take efforts to reduce the exposure with consideration of total cost, scientific impact, and protection gained. Reports of exposure histories, notifications, and investigations are presented to the Radiation Safety Committee.

Investigation Levels				
Exposure Type	**Regulatory Limit (mrem/year)**	**Goal (mrem/year)**	**Level I (mrem/qtr)**	**Level II (mrem/qtr)**
Whole Body	5,000	500	125	375
Lens of the Eye	15,000	1,500	375	1,125
Skin/Extremity	50,000	5,000	1250	3,750
Minors (whole body)	100	50	Any positive	30
Embryos/Fetus	500*	100*	33	100
Member of Public	100	25	5†	15†
Member of Public (from released patient)	500	100	25†	75†

* per 9 month gestation period

† based on calculational model

II. g. Pregnant Radiation Workers

State and federal regulations limit the radiation dose to the embryo/fetus of an occupationally exposed declared pregnant person to 0.5 rem (500 millirem) for the entire gestation. A declared pregnant person is defined in the regulations as "a [person] who has voluntarily informed the licensee, in writing, of [their] pregnancy and the estimated date of conception."

- The dose limit applies only to occupational exposures. Any radiation exposure received as a patient from medical procedures, and natural background radiation are not considered.
- The individual must provide the declaration of pregnancy in writing to impose the more restrictive limit.
- The declaration of pregnancy is strictly voluntary.

In effect, a pregnant person has the choice of declaring their pregnancy, thereby imposing a dose limit to their embryo/fetus. To comply with the more restrictive radiation dose limits, the University may require the use of additional protective equipment, increased monitoring, or re-assign work duties. Note that most activities involving exposure to radiation at the University result in annual radiation exposures less than 500 millirem.

To comply with this regulation, the University has implemented the following policy/procedures:

- The pregnant individual who wishes to impose radiation dose limits for their embryo/fetus must provide a written declaration to the Radiation Safety Officer. The RSO provides a form for making the written declaration
- Declaration of pregnancy is strictly voluntary.
- The declaration of pregnancy will be kept confidential. The declaration of pregnancy will only be disclosed to University employees and service providers with a legitimate need to know.
- A declared pregnant person may “undeclare” their pregnancy. The intent of the regulation and this policy is to give the pregnant individual the right to choose whether to impose dose limits. The individual may revoke their choice by their right to choose is irrevocable.
- A pregnant person may seek recommendations from the Radiation Safety Officer to reduce radiation exposure to their embryo/fetus without declaring their pregnancy.
- Any person may request additional information on the risks associated with radiation exposure to the embryo/fetus from the Radiation Safety Officer.
- The declared pregnant worker will notify the Radiation Safety Officer of the end of their pregnancy so that the special precautions can be terminated.
- The radiation dose limit to the embryo/fetus of a declared pregnant person is 0.5 rem (500 millirem). The radiation dose limit applies only to occupational exposure of the declared pregnant person. It does not apply to radiation exposure from medical diagnosis or treatment.
- Restrictions may be imposed to prevent radiation exposures from exceeding 500 millirem during gestation. These restrictions may include a temporary change in work assignments, the use of additional protective equipment, and increased monitoring.
- If the embryo/fetus radiation exposure has exceeded 450 millirem before the pregnancy is declared, a dose limit of 50 millirem will be in effect for the remainder of the pregnancy.
- The RSO will make efforts to avoid substantial variation above a uniform monthly exposure rate.

A pregnant worker who plans to declare their pregnancy is encouraged to do so promptly upon discovering their pregnancy so that the appropriate precautions can be taken early in the gestation period.

II. h. Obtaining Radioactive Materials

The NRC and PaDEP licenses limit the possession of radioactive materials to specifically listed isotopes. The quantity of each isotope is also limited by these licenses. Additionally, radioactive materials must be used only as authorized by the Radiation Safety Committee. Therefore, the Radiation Safety Office needs to control the receipt and possession of radioactive materials.

Ordering Radioactive Materials

- The authorized user must assure that the sum of the quantity of radioactive material currently possessed and the amount requested will not exceed the authorized user's possession limit. Radioactive waste stored in the laboratory is included in the amount possessed.
- The authorized user submits a purchase requisition to the Radiation Safety Office for review and approval. In addition to the standard requirements for a purchase requisition (cost center number, catalog number, cost, etc.), purchase requisition for radioactive material should include:
    - Authorized user's name
    - Department
    - Telephone number
    - Building and room number for delivery of the radioactive material
- Isotope, compound, and activity
- Upon approval, the Radiation Safety Office will forward the purchase requisition to the Purchasing Department for processing. Radioactive materials may not be ordered directly by the researcher.
- Radioactive materials are to be shipped to:
    - Central Receiving for the Queen Lane campus
    - Central Receiving for the Drexel main campus
    - Radiation Safety Office for the Center City campus.
- If radioactive materials are shipped from another institution (from a colleague, from a previous job, etc.), make arrangements through the Office of Environmental Health & Radiation Safety.

Receiving Radioactive Materials

Upon receipt of radioactive materials, the Office of Environmental Health & Radiation Safety is notified. The shipments are monitored for external contamination and the receipt is recorded. The laboratory is then notified that their material has arrived and is available for pick up or Radiation Safety will deliver the package directly to the lab. The authorized user is responsible for completing the "Internal Package Survey" and "Disposition of Package/Packing Material" sections of the Radioactive Material Receipt and Survey Form maintaining a copy of the completed form.

Transfer of Radioactive Materials

Transfer of radioactive material between authorized users within this University must be approved in advance by the Office of Environmental Health & Radiation Safety in writing.

Section II – General Radiation Safety Policies and Procedures

Transfer of radioactive material to another institution requires assistance from the Office of Environmental Health & Radiation Safety to assure that the receiving institution is licensed to receive and possess the material and to assure that the radioactive materials are properly packaged for shipment.

Clinical Use of Radioactive Materials

The procedures for ordering an receipt of Iodine-125 seeds for eye plaques are in Supplement 1 – Policies and Procedures for Radioactive Eye Plaques

The procedures for ordering and receipt of radiopharmaceuticals used for monoclonal antibody therapy are in Supplement 2 – Monoclonal Antibody Treatment – Radiation Safety Procedures

The procedures for ordering and receipt of radiopharmaceuticals used for diagnostic imaging are in Supplement 3 – Nuclear Cardiology – Radiation Safety Procedures

Section II – General Radiation Safety Policies and Procedures

II. i. Use and Control of Radioactive Material

1. Posting and Labeling

Posting of Laboratories and Space for Use of Radioactive Material

Doors to rooms or areas in which radioactive materials are used or stored must bear a caution label containing the radiation symbol and the words:

CAUTION RADIOACTIVE MATERIALS

Additional postings needed in laboratories with radioactive materials include:

- PADEP Notice to Employees,
- Drain Disposal sink limits and disposal chart (if sink disposal if performed),
- General Laboratory Radiation Safety Instructions,
- Emergency Instructions.

Labeling of Equipment and Containers

Equipment that contains radioactive material or is dedicated for radioactive material work need to be labeled with "Caution Radioactive Material" labels. Examples of this equipment include chemical fume hoods, refrigerators, freezers, radioactive waste containers, dedicated microcentrifuges, liquid scintillation counters.

Work areas where radioactive materials are used need to be labeled with caution tape. Examples of these areas include disposal sinks, trays, etc.

In general, containers of radioactive material need to be labeled. It is, however, not reasonable to expect that each tube or vial be labeled, but the container, tray or rack that holds them must be labeled. Stock solution vials and other containers with high specific activity solutions must be labeled.

2. Laboratory Surveys

Laboratories where radioactive materials are used must possess or have available for immediate use appropriate radiation detection equipment. This equipment must be in good working order. Radiation detection instruments must be capable of measuring the radiation from the radioisotopes in use. Geiger-Mueller (GM) survey meters are portable instruments generally capable of efficiently detecting beta radiation. Survey meters with crystal scintillation detectors are the instrument of choice to detect contamination with isotopes that emit x- or gamma radiation.

Use the survey meter to periodically check for contamination while working with radioactive material and to check for personal contamination when leaving the laboratory for breaks and at the end of the workday. Records of these surveys are not required.

The survey meter should also be used during routine surveys for removable contamination as described in the following section. Record the results of this survey on the Laboratory Survey Report Form.

Removable Contamination Surveys (Wipe Test)

Surveys for removable contamination are to be done monthly or after each experiment, whichever is more frequent. For laboratories where experiments are ongoing, perform surveys weekly. Using filter paper disks or cotton swabs, wipe work surfaces where contamination is likely. Also wipes areas where radioactive contamination is unexpected such as phones, doorknobs, computer keyboards, etc. Measure the amount of radioactivity on the samples using a gamma or liquid scintillation counter, as appropriate. Liquid scintillation counters work best for beta emitting radionuclides but can also be used for low energy gamma emitters. A crystal scintillation well counter is best for measuring gamma emitting radionuclides. The efficiency and minimal detectable activity of the counter must also be determined.

The amount of removable contamination shall be recorded in the units of disintegrations per minute (dpm) per 100 cm^2. The action level for decontamination is 1000 dpm / 100 cm^2 above background. The action level needs to be listed on the survey form used.

Records of monthly wipe surveys, and the efficiency and the minimal detectable activity of the scintillation counter are to be maintained within the laboratory and will be reviewed by the Office of Environmental Health & Radiation during the laboratory audits.

Survey Meter Recommendations

Survey meters come in many types with a variety of detection capabilities. Use a thin window GM survey meters to detect: C-14, P-32, P-33, S-35 and other medium to high energy beta emitters. Although a GM survey meter can be used to detect I-125, Tc-99m, Co-57 and other isotopes which primarily emit X- and gamma rays, a crystal scintillation detector has much higher detection efficiency. H-3 and Ni-63 cannot be detected with standard survey meters. Use a liquid scintillation detector to detect H-3 on wipe samples.

Section II – General Radiation Safety Policies and Procedures

The following provides guidance on the best type of instrument for different types of radiation sources.

Very low energy beta radiation (^{3}H, ^{63}Ni)	None
Moderate-high energy beta radiation (^{14}C, ^{35}S, ^{33}P, ^{32}P, ^{90}Sr)	Thin window (end or pancake) GM detector
Low energy gamma radiation (^{125}I, ^{103}Pd)	Thin crystal sodium iodide detector
Moderate to high energy gamma radiation (^{137}Cs, ^{60}Co)	Thick crystal (1" x 1") sodium iodide detector
Radiation levels (i.e., dose rates)	Ion chamber survey meter

3. Records of Radioactive Material Use

An up-to-date inventory of radioactive materials must be maintained. This means that the amount of radioactive material received, used, transferred, decayed, and disposed of must be documented. The Office of Environmental Health & Radiation Safety uses information to maintain an inventory for the entries University. Thus, the authorized user needs to submit reports of the use of radioactive materials to the Office of Environmental Health & Radiation Safety at the end of each calendar quarter.

II. j. General Rules for Safe Use of Unsealed Sources

- Eating, drinking, application of cosmetics, and manipulation of contact lenses are NOT permitted.
- Smoking or chewing tobacco products is NOT permitted.
- Do not store foodstuff for human consumption in the laboratory.
- Mouth pipetting is NOT permitted.
- Wear a laboratory coat.
- Wear disposable gloves and change them often. Remove and dispose of gloves prior to leaving the laboratory.
- Use drip trays where practical.
- Use plastic backed absorbent paper on work areas.
- Label radioactive work area with radioactive warning tape.
- Seal containers of radioactive material when vortexing, centrifuging, and incubating.
- Use a secondary trap flask in series with collection flask for vacuum aspiration.
- Wear radiation monitoring badge(s) if assigned.
- Monitor hands, shoes, and clothing frequently with a radiation detection survey meter.
- Wash hands after using radioactive material, before eating or smoking, and when leaving the work area.
- Survey yourself and the work area before leaving the laboratory for lunch breaks and at the end of the day, and after each high-level use of radioactive material.
- Follow the procedures for receiving radioactive material packages.
- Use acrylic shielding where practical and appropriate when manipulating ^{32}P.
- Prevent unauthorized access to radioactive material by challenging unauthorized individuals, locking radioactive material in refrigerators, freezers, or storage cabinets, or locking the laboratory when no one is physically present.
- Follow the approved protocol and any conditions of authorization.

II. k. General Rules for Safe Use of Sealed Sources

A sealed source is a source of radioactive material that is permanently bonded or fixed in a capsule or matrix. The capsule or matrix must be designed to prevent the release and dispersion of the radioactive material during conditions which are likely to be encountered in normal use and handling. Sealed sources are generally used for didactic purposes, as reference standards and in devices such as gas chromatographs, ionizing chambers, and sample irradiators.

Sealed sources must be properly labeled, shielded, and always secured from unauthorized removal. The authorized user is responsible for the source, its use, and for properly securing and shielding the source when in storage.

Handling Sealed Sources

All sealed sources greater than 100 millirem/hour at the surface must be handled with remote handling devices. All other sealed sources should be handled with remote handling devices whenever possible to reduce individual exposure. Sealed sources must be shielded or enclosed when not in active use so that the dose rate is 2 millirem/hour or less at the outside surface of the shield. This shielding/containment must also be sufficient to ensure that the exposure in any unrestricted area does not exceed 2 millirem in any one hour and does not result in a total effective dose equivalent to any individuals in an unrestricted area in excess of the 100 millirem in a year.

Sealed sources may not be opened or altered in any way. Care must be taken not to rupture thin windows covering some sources. If a sealed source is found to be dented, ripped, altered, or compromised in any fashion, the RSO must be notified immediately.

Leak Testing of Sealed Sources

The Office of Environmental Health & Radiation Safety will perform leak tests on all photon or beta emitting sealed sources in excess of 100 μCi:

- Before the source(s) is used for the first time, unless the supplier provides a certification that the source has been tested within the last 6 months; and
- At intervals not to exceed 6 months.

The Office of Environmental Health & Radiation Safety will perform leak tests on all alpha emitting sealed sources in excess of 10 μCi:

- Before the source(s) is used for the first time, unless the supplier provides a certification that the source has been tested within the last 3 months; and
- At intervals not to exceed 3 months.

Leak tests are not required on sources:

- Containing only radioactive material as a gas,
- ^{192}Ir seeds encased in nylon ribbon,
- Sources with half-lives less than 30 days.

Leak tests are not required for sources in storage provided that the sources are in the possession of the Office of Environmental Health & Radiation Safety and that the sources are clearly and conspicuously

labeled not to be used until a leak test is performed. Leak tests are not required on sealed sources being held for disposal by decay.

Special Requirements for Sealed Sources Used Off-Site

Authorization to use sealed sources at locations outside of the University campus must be approved by the Radiation Safety Committee and may require State or Federal approval. Authorized users for off-site locations shall:

- Create and maintain a use log which identifies where a source is at any time as well as identifying the person responsible for maintaining control of the source while it is in use.
- Notify the Office of Environmental Health & Radiation Safety prior to departure of the source to allow the Office of Environmental Health & Radiation Safety to inventory and leak test the source.
- Provide the Office of Environmental Health & Radiation Safety with the name of the Radiation Safety Officer at the site where the source is being shipped.
- Ensure that e that a leak test kit is included in the source shipment if the source is gone for more than 6 months. It is the responsibility of the Authorized User to ensure that a leak test is performed, analyzed, and the results are provided to the Office of Environmental Health & Radiation Safety

Sealed Source Inventory

The Office of Environmental Health & Radiation Safety will conduct a quarterly inventory of all sealed sources of radioactive material except sources acquired as exempt sources. An inventory consists of physically confirming the presence of all sources.

During the Months of March, June, September, and December, the Office of Environmental Health & Radiation Safety will conduct an inventory of all sealed sources at the University. The presence of each source must be physically observed by the person conducting the inventory.

Promptly notify the Radiation Safety Officer if a source is missing or if a source is discovered for which there is no record.

After the source inventory is completed, submit it to the Radiation Safety Officer for review and signature.

II. l Theft or Loss of Radioactive Material

Immediately after its occurrence becomes known, any lost, stolen, or missing licensed material must be reported to the Radiation Safety Officer.

The Radiation Safety Officer will determine whether, when, and which regulatory and/or law enforcement agencies need to be notified and will make any required notifications.

The Radiation Safety Officer will prepare and submit any necessary written reports. Cooperation with the RSO as information is gathered is expected.

II. m. Waste Disposal

General

Radioactive waste generated by laboratory researchers fall into the following categories:

- Animal carcasses
- Solid dry waste
- Liquid scintillation fluids and vials
- Aqueous and organic liquids

The following are the forms of disposal available for radioactive waste:

- Commercial waste disposal
- Decay in storage
- Sink disposal
- Return to vendor

Disposal Methods and Procedures for Animal Carcasses

Commercial Waste Disposal

> Double bag carcasses, label the bag with the isotope, approximate activity at the time of bagging, radiation warning label, and the date that it is placed in storage (presumably in a freezer). Notify the Radiation Safety Officer when enough carcasses have been collected that disposal is necessary. The Office of Environmental Health & Radiation Safety will arrange for commercial disposal at the next scheduled waste removal.

Decay in Storage

> Animal carcasses containing radioactive materials with a half-life less than 120 days may be stored for disposal by radioactive decay. Double bag carcasses, label the bag with the isotope, approximate activity at the time of bagging, radiation warning label, and the date that it is placed in storage (presumably in a freezer). The waste must be stored for 10 half-lives. After 10 half-lives, remove the carcasses and survey the waste. If the survey reading is indistinguishable from background, remove the radiation warning label and dispose of the waste without regard to radioactivity.
>
> Waste disposal record should include the date placed into storage, the isotope, approximate activity, the date removed from storage, the survey meter reading of the waste and the background reading, the survey meter used, and the initials of the person disposing of the waste.

Exemptions

> Animal carcasses containing 0.05 μCi per gram (50 μCi/kg) of ^{3}H or ^{14}C are exempt from disposal requirements provided that the disposal technique does not allow the carcasses to be used as human or animal food. Therefore, these carcasses can be disposed of by the normal method of disposal of non-radioactive animal carcasses.
>
> Maintain a record of the amount and activity disposed by this method.

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Disposal Methods and Procedures for Solid Dry Radioactive Waste

Commercial Waste Disposal

Solid dry waste containing isotopes with a half-life greater than 120 days must be disposed of commercially. Place the waste in a thick (4mm) polyethylene bag. Label the bag with a radiation warning label and complete and attach a radiation waste tag to the bag. The Office of Environmental Health & Radiation Safety will collect the waste and arrange for its removal by a commercial waste broker.

Note: Sealed sources should be segregated from contaminated laboratory trash.

Decay in Storage

Solid dry Solid dry radioactive waste containing isotopes with a half-life less than 120 days may be disposed by decay in storage. Segregate solid dry radioactive waste by isotope for efficient disposal by decay in storage. Remove or obliterate all radiation labels from materials placed in waste. Place the waste in a thick (4 mm) polyethylene bag. If the waste contains biologically active material that needs to be disposed of as biohazardous waste in addition to its radioactivity, use a biohazard bag. Complete and attach a waste tag to the bag. The Office of Environmental Health & Radiation will store the waste and dispose of it after it has decayed to background levels.

Disposal Methods and Procedures for Liquid Scintillation Fluids

Commercial Waste Disposal

Liquid scintillation fluids containing isotopes with a half-life greater than 120 days must be disposed of commercially. Place the waste in a thick (4 mm) polyethylene bag. Label the bag with a radiation warning label, and complete and attach a radiation waste tag to the bag. The Office of Environmental Health & Radiation Safety will collect the waste and arrange for its removal by a commercial waste broker.

Decay in Storage

Liquid scintillation fluids containing isotopes with a half-life less than 120 may be disposed by decay in storage. Segregate liquid scintillation waste by isotope for efficient disposal by decay in storage. Place the waste in a thick (4mm) polyethylene bag. Label the bag with a radiation label, and complete and attach a waste tag to the bag. The Office of Environmental Health & Radiation Safety will store the waste and dispose of it after it has decayed to background levels.

Sink Disposal

Sink disposal is permitted if the chemical constituents of the liquid scintillation fluid permits disposal into the sewer. Follow sink disposal procedures outlined by University policies.

Exemptions

Liquid scintillation fluids containing 0.05 µCi per gram (50 µCi/kg) of ^{3}H or ^{14}C are exempt from disposal requirements. Segregate ^{3}H and ^{14}C liquid scintillation waste so that the University can take advantage of this exemption. The fluid may require special handling because of the chemical

form of the liquid scintillation fluid. The Office of Environmental Health & Radiation Safety will arrange for the disposal of this type of waste, therefore, follow the instructions for commercial disposal.

Disposal Methods and Procedures for Aqueous and Organic Liquids

Sink Disposal

Sink disposal of radioactive materials is regulated based on the radioactive properties and the chemical properties of the material being disposed.

Each authorized user utilizing sink disposal must be specifically approved for disposal in a designated sink within the laboratory. Each designated sink is to be outlined in radioactive warning tape and sink disposal limits signage must be posted near the sink. Assigned sink disposal limits are not to be exceeded. Records of all sink disposals must be maintained on the Sink Disposal of Radioactive Material Log. Only readily soluble or biologically dispersible materials may be disposed in the sink. Compound must be "soluble" or "very soluble" in the CRC Handbook of Chemistry & Physics (or other similar reference). Each sink is to be swiped and surveyed by the researcher and documented after each experiment or at a minimum of one-month intervals. If the contents of liquid scintillation vials are sink disposed, the empty vials may be placed in regular trash after triple-rinsing.

Sink disposal is subject to regulations based on the chemical nature of the waste as well. Therefore, compliance with the University Chemical Hygiene Plan is necessary. Contact The Office of Environmental Health & Radiation Safety.

Commercial Waste Disposal

Liquids containing isotopes with a half-life greater than 120 days that cannot be disposed into the sink may be disposed commercially after the waste is solidified. Contact the Office of Environmental Health & Radiation Safety to make arrangements for disposal.

Decay in Storage

Liquid waste containing isotopes with a half-life less than 120 days may be disposed of by decay in storage. Segregate liquid waste by isotope for efficient decay in storage disposal. Place the waste in an unbreakable container (e.g., plastic carboy) compatible with the chemical contents. The Office of Environmental Health & Radiation Safety will store the waste and dispose of it after it has decayed to background levels.

II. n. Emergency Procedures

Reporting and Investigating Radiation Incidents

While performing laboratory research procedures, there is the possibility that radioactive materials spill or an incident involving radiation producing equipment can occur. Depending on the nature of the incident, an investigation will be conducted to determine:

- Hazard impact on personnel,
- What steps can be taken to prevent recurrence,
- Whether established procedures are adequate to cover such incidents.

The response to an incident depends on the nature of it. The most likely incidents in a research laboratory are spills and fires. Any incident involving radioactive materials must be promptly reported to the Office of Environmental Health & Radiation Safety.

Minor Spills

A spill is defined as leaving the confines of the experiment. Therefore, a discharge onto absorbent paper or drip tray is not a spill. An incident can be considered minor if all the following are true:

- The nature and potential hazards are known
- There is no contamination of personnel
- There is no release of radioactive material into unrestricted areas
- There is no airborne radioactive material
- There are no injuries besides those not involving radioactive material and not needing medical attention
- There is no potential uptake of radioactive material and there is no radiation hazard to personnel

In the event of a minor spill:

- Notify all other persons in the room/area where the spill occurred.
- Prevent the spread of contamination by covering the spill with absorbent material.
- Decontaminate the area using paper towels or absorbent pads, starting from the outside of the spill, and moving toward the center. Place all waste into a plastic bag and submit for disposal as radioactive waste. Disposable gloves, a lab coat, and, if appropriate, shoe covers must be worn. Cleaning agents may be used after initial decontamination using a radiation decontaminant (e.g., Bind-It, Radiacwash, NoCount, etc.).
- Survey the area and all potentially contaminated and potentially contaminated individuals with a G-M survey meter. Survey for removable contamination using wipe samples.
- Report the incident to the Office of Environmental Health & Radiation Safety.

Major Spills

An incident is considered a major spill if any of the following are true:

- The nature or potential hazard cannot be ascertained
- The is personal contamination (skin or street clothes)
- There is a release of radioactive material into unrestricted areas

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- Airborne radioactive material is generated
- There are injuries which may involve radioactive material
- There are injuries which require medical attention
- There exists the potential for an uptake of radioactive material
- Fire or explosion
- Evacuation of the room or building is necessary

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

- Clear the area and vacate all persons from the room.
- Cover the spill with absorbent paper. Do NOT attempt to clean it yourself.
- Assemble all potentially contaminated personnel near the room entrance.
- Close and prevent entry into the room.
- Immediately contact the Office of Environmental Health & Radiation Safety (215-895-5919).
- Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by EHRS. Contaminated skin should be flushed thoroughly and then washed with mild soap and lukewarm water.

Fires

In the event of a fire in a laboratory, follow RACE procedures:

1.) **Remove:** Remove everyone in immediate danger if you can do so without endangering yourself.
2.) **Alarm:** Sound the alarm by pulling a fire box. Call the Public Safety 24-Hour Call Center at (215) 895-2222. Notify the dispatcher of the precise location of the fire.
3.) **Confine:** Confine the smoke and fire by closing all doors and windows. Shut off the piped and compressed gas as you evacuate.
4.) **Evacuate:** Evacuate the building:
    - Incase of alarm, evacuate the building using the nearest exit. Identify a backup exit.
    - Do not use elevators during a fire alarm.
    - Do not enter a room if the door is warm to the touch or if the room is filled with smoke.
    - Make sure stairwell doors always remain closed and unobstructed.
    - Account for all staff at your departments designated muster location.

Operating a fire extinguisher: P.A.S.S.

- **Pull** the pin
- **Aim** at the base of the fire
- **Squeeze** the handle
- **Sweep** from side to side

Only attempt to extinguish a fire if you have been trained in the proper use of an extinguisher. Only small fires can be extinguished; always be prepared to evacuate.

DO NOT attempt to extinguish the fire if radioactive materials are directly involved. Evacuate the area, contact Environmental Health & Radiation Safety, and notify firefighters of the radioactive materials that are involved.

All incidents, along with the Radiation Safety Officer's assessment, will be reported to the Radiation Safety Committee.

II. o. Enforcement Policy

This policy exists to create and implement procedures to deal with issues of noncompliance. The RSO is given the authority to assign a level of violation to an individual and assign their outcome as a result. The RSO may raise the level of violation with repeated instances of non-compliance to written communications from the Office of Environmental Health & Radiation Safety.

This policy has been created with the purpose and objectives of the enforcement procedures:

1.) As a deterrent to emphasize the importance of compliance with requirements; and
2.) To encourage timely identification and prompt correction of violations.

Severity Levels of Violations

	Violation	Enforcement Action
Level 1	Items which are of an immediate threat to health and safety (e.g., production of airborne radioactive material in the laboratory)	Immediately shut down lab, revoke the individual's license and remove radioactive materials from the premises for storage by the Office of EHRS
Level 2	Items which pose a threat to health and safety or which could result in civil penalties against the University (e.g., using unlicensed materials, unrestricted access to radioactive materials)	Give notice to the researcher that their actions are in jeopardy of causing the denial of requests to purchase radioactive materials, closure of the lab, revocation of their license, and/or removal of radioactive materials from the researcher's possession. Notify the Provost, Vice President, Dean, and/or Department Chair of the situation. Give the individuals 48 hours to respond to the situation
Level 3	Items which have the potential for significant to health, safety, and compliance (e.g., performing unauthorized experiments)	Give written notice to the researcher and the Vice President/Department Head that the researcher's actions are potentially problematic in reference to the University license. Give the researcher and Vice President/Dean a 14-day period in which to respond to the situation
Level 4	Items which individually have only a minor effect on health and safety but if continued, could significantly affect compliance, health, or safety (e.g., missing a survey, failure to record survey)	Give the researcher notice as to the nature of the violation. Give the individual a 30-day time period in which to rectify the situation
Level 5	Minor paperwork which has little bearing on health, safety, or compliance is not present in the lab (e.g., copy of Radiation Safety Manual in lab)	Provide authorized user with the materials necessary to comply with policy

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Exercise of Discretion

The ability to exercise discretion is preserved within this policy. Discretion is provided to deviate from the normal approach to either increase or decrease sanctions where necessary to ensure that the sanction reflects the significance of the circumstances and conveys the appropriate message.

Escalation of Enforcement

For repeated failure to correct a Level 3 or 4 violation or for failure to promptly respond to and correct a Level 2 violation, the Radiation Safety Officer may, upon consultation with the Chair of the Radiation Safety Committee, deny requests for the purchase or acquisition of radioactive material.

Sanctions may be increased due to repeated failure to correct the problem, failure to respond to the notice of violation, or multiple occurrences of a violation or multiple violations which indicate a lack of oversight of radiation safety in the laboratory. The purpose of aggregating violations is to focus attention on the fundamental underlying causes for which enforcement action appears warranted, and to reflect the fact that several violations with a common cause may be significant collectively, enough so that an escalation in violation level may be appropriate.

Sanctions may be decreased due to prompt corrective action, good past performance, and/or self-identification and correction.

Enforcement Actions

Notice of violation: Any written notice of violation at Level 4 or above requires the recipient to provide a written statement describing:

- The reasons for the violation
- Corrective steps that have been taken
- Corrective steps that will be taken
- The date when full compliance will be achieved

This policy will be enforced by the Radiation Safety Committee and the Office of Environmental Health & Radiation Safety as needed. The RSO will review the responses submitted and decide the course of action. The decision of the Radiation Safety Officer may be appealed to the Radiation Safety Committee. After a year of acceptable audits, an individual will be considered in good standing with the University policy.

Section III – Specific Uses of Sources of Radiation

III. a. Radioiodines

There are occasions where experiments require the labeling of compounds with radioactive isotopes of iodine (radioiodine). Iodine salts, in the presence of hydrogen ions (i.e., acids), are relatively volatile; therefore, represent a possible exposure through inhalation. Because of this possible inhalation exposure, use of exhaust hoods is mandatory for iodination procedures. To ensure that the release of radioiodines into the environment is within standards, monitoring of air effluents may be necessary. Finally, the amount of radioiodine taken into the body (and concentrated in the thyroid gland) may need to be assessed.

The following procedures are in place to minimize radiation hazards associated with iodination procedures and to monitor radioiodine released to the environment. These procedures are to be followed for all iodination procedures.

- Iodination procedures shall be performed only by specifically authorized individuals in:
    - Specifically designated laboratories and
    - Specifically designated exhaust hoods
- Exhaust hoods to be used must be/have:
    - Unless deemed unnecessary by the Radiation Safety Officer, an air sampling system must be in place to sample effluents released.
    - Average face velocities greater than 80 ft/min and less than 120 ft/min. Velocities to be checked annually by Drexel University Department of Environmental Health & Radiation Safety or their designated vendor.
    - Covered with poly-backed absorbent paper to absorb possible spills and drips.
    - Effluents released directly to outside areas which are relative uninhabited (no recirculating airflow).
- Unless deemed unnecessary by the Radiation Safety Officer, personnel involved in iodination procedures must have a baseline thyroid bioassay prior to iodinating and a thyroid uptake bioassay 24 to 72 hours after completion of the procedure.
- The day before performing an iodination, notify the Office of Environmental Health & Radiation Safety. The Office of Environmental Health & Radiation Safety will assure air sampling system is operational and record flow volume rate and time sampling begins.
- During an iodination the researcher is responsible for assuring that:
    - Iodination work done is performed totally within the exhaust hood.
    - Air sampling system is operating (leave on for whole procedure)
    - A survey meter is present and operational. Ideally the following would be available for use:
        - ^{125}I – Crystal scintillation detector (available on loan from the Office of Environmental Health & Radiation Safety)
        - ^{131}I – GM (end window or pancake) detector
    - Exhaust hood sash is kept as low as consistent with the proper performance of the exhaust hood and the iodination procedure.
    - At least 2 layers of gloves, a lab coat, and assigned dosimeter are worn during the iodination.

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- After iodination:
  - Turn off the air sampling system and record the time and the air flow volume rate.
  - Record the duration of the iodination in minutes.
  - Call the Office of Environmental Health & Radiation Safety to recover the filter for effluent measurement.
  - Arrange for thyroid uptake bioassays.
  - Clean up the exhaust hood.
  - Thoroughly survey the entire area including floors, hood, equipment, waste container outer surfaces, hands, feet, and clothing.
  - Perform wipe tests of the hood, floors, and any countertop surfaces utilized during the iodination.

III. b. Guidelines for Use of Radioactive Materials in Animals

Protocol Approval

Protocols involving animals and the use of radioactive materials are reviewed and approved by the Radiation Safety Committee, the Institutional Animal Care and Use Committee (IACUC), and the University Laboratory Animal Resources Facility (ULAR). If necessary, amend your authorization to include the isotopes and rooms where the animal work is performed. Include the ULAR facility if the animal will contain radioactive material while being housed there and include any imaging locations such as Nuclear Medicine, MRI, etc.

Submit a completed application to use radioactive materials and an animal use supplement form to the Radiation Safety Committee.

Use of Animals in Laboratory

Follow procedures for use of RAM as listed in this manual and as specified in your authorization to use radioactive materials. Dispose of euthanized animals and animal bedding as radioactive waste, as appropriate. Survey animal cages and decontaminate as necessary prior to returning to the animal facility or to non-radioactive use.

Using Radioactive Material in ULAR

Animal care is the responsibility of the authorized user while the animals are radioactive. Post cages and rooms with "CAUTION RADIOACTIVE MATERIALS" warning signs. Place a suitable container in the room to hold any waste generated during the procedure. Label the container with "CAUTION RADIOACTIVE MATERIALS" warning label.

Monitor the cages, equipment, and rooms for removable contamination with a suitably sensitive survey method before the room is released for unrestricted use, and weekly during the time that the animals contain radioactivity. Document the results in your lab records. Contact the Office of Environmental Radiation Safety if you need assistance.

Remove radioactive waste and transfer to the Office of Environmental Health & Radiation Safety.

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Transporting Animals Containing Radioactivity

Transfer animals in a manner to prevent release of radioactive material to unrestricted areas. Depending on the animal, it may be necessary to catheterize, anesthetize, use enclosed containers, etc. Label and shield the container if necessary.

III. c. Clinical Research and Trials

The Committee for the Protection of Human Subjects (also known as the Institutional Review Board or IRB) reviews all research protocols involving human subjects. Human research subjects may be exposed to radiation as part of an investigational research program. These exposures may be either:

- Standard diagnostic or therapeutic clinical procedures involving the administration of radiation or radioactive materials; or
- New, non-standard, or novel administrations of radiation or radioactive material

The primary radiation safety considerations are:

- The radiation exposure is justified by the quality of the study being undertaken.
- The protocol is configured such that the subject receives the smallest radiation dose with which it is practical to perform the study without jeopardizing the benefits to be obtained from the study.
- Radiation dose to the subject must be quantified and made available to the IRB for consideration. Of particular concern are potentially pregnant individuals and minors.
- Informed consent which accurately outlines procedure and risks must be obtained from the research subject or legally authorized representative.

In addition to the information required by the Committee for the Protection of Human Subjects, applications submitted for protocols including the administration of radiation or radioactive materials must contain as least the following information:

- Description of the diagnostic or therapeutic procedure(s) resulting in a radiation exposure to the human research subject and the justification for such exposures.
- An estimate of the radiation dose to the human research subject when the administration of radiation or radioactivity is not a routine diagnostic or therapeutic procedure.

Classification

Research proposals involving application of radiation or radioactive materials to human research subjects are categorized into 3 classes as follows:

Class 1: The radiation exposure or administration of radioactive material is a standard clinical procedure that the individual as a patient would have received anyway. The procedure is standard of care for this population of human subjects.

Class 2: The radiation exposure or administration of radioactive material is a routine clinical procedure that the individual would not normally receive as a patient but may or will receive as a human subject if enrolled in the research project.

Class 3: Radiation exposure from new, novel, non-standard, or off-label procedure.

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Procedures for approval is dependent on the class under which the proposed protocol involving human use falls:

> Class 1: The Radiation Safety Officer will review the informed consent for accuracy regarding the radiation exposure and risks.
>
> Class 2: Application and associated consent form will be reviewed by the Radiation Safety Officer. The Radiation Safety Officer shall ensure that the radiation doses are appropriately documented. Full review by the RSC will not be necessary.
>
> Class 3: Application and associated consent forms must be reviewed by the Radiation Safety Committee. The Committee may enlist subject matter experts to assist with the review if needed.

Relationship between the IRB and the RSC

- Protocols falling under Class 2 or 3 will be referred to the Radiation Safety Officer as they are received by the Office of Research / IRB.
- The Radiation Safety Officer will review informed consent for accurate statements of radiation doses and risks.
- Approval or recommendations of the Radiation Safety Officer will be forwarded to the IRB through the appropriate Office of Research IRB Coordinator.
- Class 3 applications and Radiation Safety Officer recommendations will be submitted to the Radiation Safety Committee for approval.
- Final decisions regarding approval of the research protocol reside with the IRB.

Informed Consent

If radiation or radioactivity is administered for research purposes (i.e., it is not standard care) then the administration must be disclosed on the informed consent. This disclosure is to include:

- A description of the procedure
- A statement of the risk

The following example statements may be modified and used as appropriate:

- For a chest X-ray (or other low dose x-ray procedures such as extremity and dental radiography, and DEXA scans)

  > This research study involves exposure to radiation from x-rays and therefore you will receive a radiation dose. This radiation dose is not necessary for your medical care and will occur only as a result of your participation in the study. At doses much higher than you will receive, radiation is known to increase the risk of developing cancer after many years. At the dose you will receive, it is very likely that you will see no effects at all.
  >
  > This research study involves exposure to radiation from x-rays. X-rays are routinely used for medical purposes. This radiation dose is not necessary for your medical care; you will receive it only as a result of your participation in this study. The radiation dose that you will receive is less than the natural environmental radiation the average person receives in the United States annually. A primary risk associated with radiation dose is the

possibility of developing radiation induced cancer later in life. But the risk from radiation exposure from a chest x-ray is considered to be negligible when compared to everyday risks.

This research study involves exposure to radiation from a chest x ray. The amount of radiation exposure from this is equivalent to a radiation exposure over the whole body of about 6 millirem. This is equivalent to 2% of the average amount of radiation received from the natural environment in a year. The risk from this amount of radiation is too small to be measured.

- For a CT scan

  This research study involves exposure to radiation from a CT scan of the _____ and therefore you will receive a radiation dose. This radiation dose is not necessary for your medical care and will occur only as a result of your participation in the study. At doses much higher than you will receive, radiation is known to increase the risk of developing cancer after many years. At the dose you will receive, it is very likely that you will see no increased risks or effects at all.

- For less than 5 additional chest/abdomen/pelvis, 7 additional abdomen/pelvis, or 10 additional abdomen or pelvis CT scans

  You will receive more frequent CT scans as a part of this research protocol than you would otherwise receive as standard medical care. These tests will result in radiation exposure to you. At doses higher than you will receive, radiation is known to increase the risk of developing cancer after many years. At the dose you will receive, it is very likely that you will see no effects or increased risks at all.

- For more than 5 additional chest/abdomen/pelvis, 7 additional abdomen/pelvis, or 10 additional abdomen or pelvis CT scans

  You will receive more frequent CT scans as a part of this research protocol than you would otherwise receive as standard medical care. These tests will result in a radiation exposure to you. Radiation is known to increase the risk of developing cancer. At the dose you will receive, there is a small increase in the risk of developing cancer several years from now.

- For MUGA scan:

  This research study involves exposure to radiation from a MUGA scan. For this scan a small amount of radioactive material will be injected into a vein in your arm. A nuclear medicine camera will be used to create an image of the blood flow through your heart. This is a standard diagnostic test; however, it is not necessary for your medical care. The MUGA scan is being performed as a result of your participation in this study. The risk from the radiation exposure you will receive is minimal. The calculated radiation dose is available upon request.

Section III – Specific Uses of Sources of Radiation

- For Nuclear Cardiology Stress Test

  This research study involves exposure to radiation from a nuclear stress test. A small amount of radioactive material will be injected into your arm. A nuclear medicine camera will be used to create an image to show whether your heart muscle is getting enough blood. This is a standard diagnostic test; however, it is not necessary for your medical care. The MUGA scan is being performed as a result of your participation in this study. The amount of radiation from this test is unlikely to cause any harmful effects. The calculated radiation dose is available upon request.

- For cardiac catheterization procedures

  You will receive a radiation exposure from the x-ray images of your heart. Your lungs, bones and heart will receive a radiation exposure, but the highest radiation exposure will be to your skin. Very high skin exposures can cause reddening of the skin (like a sunburn), blistering and even ulcerations. Unless we run into unexpected complications requiring us to do a lot more x- ray imaging than normal, you should not see any complications from the radiation exposure. Risks to your lungs, bones, and heart from the x-ray pictures are small and are considered comparable to other everyday risks.

  You will receive a radiation exposure from the x-ray images of your heart. Your lungs, bones and heart will receive a radiation exposure, but the highest radiation exposure will be to your skin. Very high skin exposures can cause reddening of the skin (like a sunburn), blistering and even ulcerations. Additional x-ray images are needed because of the research procedures. The extra imaging is not enough to cause these effects. So, unless we run into unexpected complications requiring us to do a lot more x- ray imaging than normal, you should not see any complications from the radiation exposure. Risks to your lungs, bones, and heart from the x-ray pictures are small and are considered comparable to other everyday risks.

- For interventional fluoroscopy and other procedures with high skin doses, adapt the above as appropriate.

Section III – Specific Uses of Sources of Radiation

III. d. Irradiators

Introduction

Self-shielded irradiators are self-contained devices in which the shielding required for operation is an integral part of the device and the irradiation chamber is not accessible during operation. Typically, one or more high activity cesium-137 (Cs-137) sources are used in these irradiators.

The Office of Environmental Health & Radiation Safety must be notified before any new irradiator purchase or replacement of an existing unit.

Authorized User Responsibility

All irradiator use must be under the supervision of an authorized user who has been approved by the Radiation Safety Committee. The authorized user must assure that irradiator operators are properly trained. It is the responsibility of the authorized user to assure that operations are conducted in accordance with the irradiator operating and emergency procedures, and license conditions. To ensure proper operation of the unit, the authorized user needs to perform visual inspections and operational checks according to the manufacturer's written instructions and recommendations.

The Office of Environmental Health & Radiation Safety must be notified promptly of any malfunction of the irradiator and before any maintenance or repair work is performed.

Posting and Labeling

Labels bearing the radiation symbol, type of source, manufacturer and licensee information is required to be on each irradiator. Current copies of the following documents must be kept at each irradiator:

- Irradiator’s User’s Guide
- Operation procedure
- Emergency procedure
- Irradiator use log
- NRC Form 3 “Notice to Employees”

Training and Registration

Each user of the irradiator must be trained in appropriate radiation safety and operational procedures for the use of the irradiator. This training is separate from (and in addition to) other radiation safety training provided by the Office of Environmental Health & Radiation Safety.

Before using an irradiator, all persons must be trained by the authorized user (or their designee) in the safe and proper operation of the irradiator. Training by the authorized user must cover the following:

- Step-by-step operating procedures
- Emergency procedures
- Security procedures
- Design and operation of the unit
- Observation of an irradiation Procedure
- Performance of an irradiation procedure under the supervision of a trained operator

Section III – Specific Uses of Sources of Radiation

Prohibited Uses

The irradiation of flammable or explosive materials is prohibited.

Maintenance or repairs involving removal of the source, safety devices, or shielding components may only be performed by the manufacturer or a contractor that is specifically licensed to do so and who has provided documentation of trustworthiness and reliability. Notify the RSO prior to arranging this service. The RSO will check the license and other security related documentation.

Radiation Hazard

Self-shielded irradiators typically contain several hundred to several thousand curies (Ci) of Cesium-137 (Cs-137) and range in weight from several hundred to several thousand pounds. The Cs-137 is doubly encapsulated in stainless steel to form a sealed source which is not dispersible as long as the integrity of the encapsulation is not compromised.

The design of the irradiator is required to provide shielding (primarily lead) so that external radiation levels are low.

Personnel Exposure Monitoring

Because the radiation levels surrounding the irradiator are low, personal radiation monitoring is not necessary. However, monitoring devices may be issued to personnel working with the irradiator at the discretion of the RSO.

Irradiator Malfunction

In the event of a malfunction, triggering of an alarm on a meter, or an unusual occurrence:

- Do not attempt to fix the irradiator;
- Turn off the machine, if possible;
- Leave the room;
- Call the Office of Environmental Health & Radiation Safety immediately.

Security

Only approved individuals will be granted unescorted access to the irradiator.

Report any of the following situations to Public Safety and Radiation Safety immediately:

- Suspicious persons or activity,
- Evidence of tampering with the unit or security devices,
- Individual(s) asking inappropriate questions regarding the irradiator, its location, access control to it, etc.

Section III – Specific Uses of Sources of Radiation

III. e. X-Ray Machines

Use of x-ray equipment in Pennsylvania is regulated by the Pennsylvania Department of Environmental Protection (PaDEP). The PaDEP has established regulations which must be followed by all individuals using energized (x-ray) equipment. These regulations are found in Title 25 of the Pennsylvania Code and are available for review in the Office of Environmental Health & Radiation Safety or on the PA Code website at www.pacode.com.

All x-ray equipment must be registered with the Radiation Safety Office. The Radiation Safety Office must be notified prior to modification, relocation, disposal, or transfer of x-ray producing equipment. This includes moving equipment to a different room within the same building.

All individuals using x-ray producing equipment must register with the Radiation Safety Office. This may be accomplished by completing the Radiation Worker Registration Form in the back of this guide and submitting it to the Office Environmental Health & Radiation Safety.

Analytical X-ray Units

Analytical X-ray units typically have X-ray beams that are:

- Very high intensity,
- Very narrow, and
- Low energy.

The x-ray energy is such that inherent shielding in the equipment adequately reduces the radiation levels. However, the beam can cause serious, permanent radiation damage if the inherent shielding has been compromised. Of primary concern are fingers when manipulating targets. Under normal circumstances, the safety features of these units prevent accidental exposures. Therefore, adherence to the safety procedures below and to the operating and emergency instructions specific to the analytical x-ray unit is essential.

Analytical x ray units will be equipped with an easily visible warning light located immediately adjacent to the tube head or port and labeled with the words “X-ray on,’’ or words containing a similar warning. The warning light will be illuminated when the X-ray tube is energized.

Any unused ports on the radiation source housing must be secured in the closed position in such a way that prevent casual opening.

The x-ray source housing must be labeled with a sign that includes the standard radiation warning symbol and the wording: “CAUTION—HIGH INTENSITY X-RAY BEAM’’ (or words to that effect).

A label near all switches that energizes the x-ray tube must include the standard radiation warning symbol and the wording: “CAUTION RADIATION—THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED,’’ (or words to that effect).

Warning devices shall be labeled so that their purpose is easily identified and shall have fail-safe characteristics.

When all the shutters are closed, the leakage radiation 5 centimeters from the housing may not exceed 2.5 milliroentgens (.645 μC/kg) per hour. Leakage around the X-ray generator may not exceed 0.5 milliroentgen (.129 μC/kg) per hour at 5 centimeters from the housing surface.

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The radiation levels surrounding the analytical x-ray unit and any components attached to it (e.g., shutter assemblies, cameras, collimators, etc.) must be such that an individual present in the area will not exceed the dose limits for members of the public (e.g., 100 millirem in a year).

Written operating procedures must be made available to the analytical x-ray equipment users. These procedures shall include instructions for sample insertion and manipulation, equipment alignment, routine maintenance and data recording procedures which are related to radiation safety. An individual may not operate analytical X-ray equipment in a manner other than that specified in the operating procedures unless the individual has obtained written approval from the Radiation Safety Officer.

Prior written approval of the radiation safety officer is required to bypass or otherwise circumvent a safety device. Approval will not be granted unless:

- Administrative controls and procedures have been established to protect individuals working around the system from radiation;
- The safety device is not bypassed for more than 30 days; and
- A conspicuous sign stating ‘‘SAFETY DEVICE NOT WORKING,’’ or words to that effect is placed on the radiation source housing.

Except when written approval is given by the radiation safety officer to override safety devices, operations involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators or beam stops may not be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored. Interlocks may not be used for routine shutdown in preparation for repairs; use the main switch.

Written emergency procedures will be posted near the equipment and include the names and telephone numbers of personnel to contact. The emergency procedures will also provide information necessary to de-energize the equipment, such as location and operation of the power supply or circuit breakers.

Individuals must receive instructions and demonstrate competence in the following subjects before they are permitted to operate or maintain analytical x-ray equipment:

- Identification of radiation hazards associated with the use of the equipment.
- Significance of the various radiation warning and safety devices incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment, and the extra precautions necessary if the devices are absent or bypassed.
- Written operating and emergency procedures for the equipment.
- Symptoms of an acute localized radiation exposure.
- Procedures for reporting an actual or suspected exposure.
- Use of survey and personnel monitoring equipment.
- The applicable regulations.

All x-ray diffraction equipment will be surveyed upon installation and annually as a matter of routine by the Radiation Safety Office. The survey includes tests and inspections of all safety and warning devices to ensure their proper operation. (A copy of the survey forms is in the Forms section at the end of this manual.) Surveys are also required whenever any of the following occurs:

- When there is a change in the initial arrangement, number, or type of local components in the analytical unit system.

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- Following maintenance requiring the disassembly or removal of a local component.
- During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when a local component in the system is disassembled or removed.
- When a visual inspection of the local component in the system reveals an abnormal condition.
- When the machine is operated in a manner other than the routine manner specified in the written operating manual.
- When personal monitoring devices show a significant increase in radiation exposure over the previous monitoring period or the readings are approaching the radiation dose limits.

Contact the Office of Environmental Health & Radiation Safety whenever any of the above conditions occurs so that a survey can be conducted.

Exposure to scattered radiation from analytical x-ray equipment is extremely low. Therefore, personnel dosimetry is not required for routine operations. However, personal dosimeters including finger dosimeters, are required for persons performing maintenance on x-ray diffraction units, when a local component in the system is disassembled or removed, or when safety devices are disabled.

The dose reported on the personal monitoring device may not be the actual dose to the individual; therefore, it must be evaluated by the Radiation Safety Officer. If there is reason to believe that an individual may have been exposed to the x-ray beam, contact the Office of Environmental Health & Radiation Safety immediately. Any suspected radiation overexposure to an individual from analytical X-ray machines will be reported to the PADEP within 5 days of its discovery. Notification is required even if the subsequent investigation reveals no actual over-exposure occurred.

Open Beam Systems

An open beam configuration system is an analytical x-ray system in which the beam is not enclosed or shielded so any portion of an individual's body, including fingers, could accidentally be placed in the beam path during normal operation.

The following additional requirements apply to individuals operating open beam systems.

Open-beam systems will have a safety device which either prevents the entry of any portion of an individual’s body into the primary X-ray beam path or causes the beam to be terminated or interrupted upon entry into the path.

Open-beam systems will be equipped with a conspicuous indicator of:

- The status of the x-ray tube (on or off) located near the radiation source housing if the primary beam is controlled in this manner.
- The status of the shutter(s) (open or closed) located near each port on the radiation source housing if the primary beam is controlled in this manner.

Each port on the radiation source housing an open beam system shall be equipped with a shutter that cannot be opened unless a collimator or coupling has been connected to the port.

Workers using open-beam systems will be issued and will be required to wear finger or wrist personal monitoring devices.

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X-Ray Machine Use with Laboratory Animals

Proper Operating Procedures for Radiographic Units

- Limit the X-ray primary beam to the smallest area possible consistent with the objectives of the clinical examination.
- Align the X-ray beam properly with the animal and the image receptor.
- Remain behind a protective barrier (i.e., a leaded glass wall, a leaded door, etc.) during radiographic exposure.
- Provide protective garments (lead aprons/shielding) for everyone whose presence is necessary during radiographic exposure.
- Whenever possible, use restraining, supporting, or positioning devices for the animal. An individual holding or supporting an animal or film during radiation exposure shall wear protective gloves and apron having a lead equivalent of not less than 0.5 millimeter and shall be positioned so that no part of that individual's body will be struck by the useful beam. The exposure of an occupationally exposed individual used for this purpose shall be monitored.
    - No individual may be regularly employed to hold or support animals or hold film or hold the x-ray tube head during radiation exposures. Occupationally exposed individuals may not perform this service except in cases in which no other method is available.

Proper Operating Procedures for Fluoroscopic Units

- Only persons required for a fluoroscopic procedure should be in the room during the procedure.
- As in a radiographic procedure, use the smallest possible beam area, thereby reducing the scatter radiation to personnel.
- Fluoroscopic doses can also be minimized by a reduction in the fluoroscopic time used. Use the timing device to indicate a preset time to serve as a reminder to keep it as short as possible.
- Use the shortest possible distance from the image intensifier to the animal.
- Lead aprons and thyroid shield should be worn when performing fluoroscopic procedures.
- Lead gloves should be worn if the hands may be in or near the x-ray beam.

Each radiographic room has been designed with sufficient shielding in the walls to provide protection to anyone on the outside of the room. Notify the Office of Environmental Health & Radiation Safety before making any changes which may affect the integrity of the shielding such as holes drilled into walls.

Notify the RSO prior to or upon acquisition and disposal of any radiation producing equipment.

Section III – Specific Uses of Sources of Radiation

Electron Microscope

The term "electron microscope" includes equipment utilizing the wave characteristics of electrons that have been accelerated by an electric field to visualize the microscopic structure of material.

Individuals may not operate or conduct maintenance on any electron microscope until they have received a copy of, instruction in, and demonstrated an understanding of, the operating procedures necessary to ensure radiation safety.

A warning label will be conspicuously posted on the electron microscope which states, "Caution Radiation - This Equipment Produces Radiation When Energized", or words containing a similar warning.\

Radiation levels measured 5 centimeters from any accessible surface of an electron microscope are not permitted to exceed 0.5 milliroentgen per hour (0.5 mR/h). Surveys are performed annually to confirm that this radiation level is not exceeded.

III. f. Radiation or Radioactive Materials in Educational Activities

Radioactive materials may be used in classrooms for student education purposes. These procedures are designed to minimize the potential for radiation exposure to students.

Demonstrations or educational laboratory exercises with radioactive materials may include the use of exempt quantity sources, general licensed material, or specific licensed material. The use of exempt quantity sources (i.e. check sources) does not require prior approval by the Radiation Safety Committee. However, any use of general or specific licensed material must have prior Radiation Safety Committee approval. The application to the RSC must include:

- Faculty member responsible for the course
- Individual(s) performing the laboratory exercise (if different from the faculty member)
- Location (building and room)
- Description of the procedures, including laboratory instructions to students
- Contamination control procedures
- Required personal protective equipment
- Closeout survey procedures

Educational or student laboratory activities involving radioactive materials may only be conducted as authorized by the Radiation Safety Committee. For such activities the following is observed:

- Authorized user or trained designee must be present throughout activity.
- After completion of activity, the area must be surveyed (swipe and/or survey meter as determined by the RSO).
- Results of survey will be recorded in users disposition log, including quantities of radioactive materials used.

III. g. Minors Working with Sources of Radiation

Individuals (typically students) less than 18 years of age employed on a part-time basis or as part of a training program, may on occasion enter areas where they may be exposed to radiation either from x-ray machines or from radioactive materials. Dose limits for minors are 10% of the dose limits for adults. Therefore, if minors may be exposed, more stringent precautions must be taken.

The sponsor/supervisor of a minor will notify Office of Environmental Health & Radiation Safety in writing for each minor with the following information:

- Name of the minor
- Minor's affiliation with the University
- Period of time minor will work with source of radiation
- Description of students' activities with sources of radiation
- Confirmation that the sponsor/supervisor will be directly responsible to assure that all precautions and appropriate procedures are followed.

Maximum permissible levels for minors are:

500 millirem/year (5 mSv/year) effective dose
1500 millirem/year (15 mSv/year) to eye lens
5000 millirem/year (50 mSv/year) to extremities and skin

All minors will be instructed as follows by the sponsor/supervisor:

- Activities they can and cannot do (see below)
- Specific protocols for activities in which minor is engaged
- Laboratory/x-ray safety procedures
- Emergency/spill procedures
- Location and use of safety equipment
- Care of personal radiation dosimeters (if applicable)

In addition to the standard requirements for working in a facility where sources of radiation are used or stored, the following restrictions apply:

- No experiments with activities in excess of 25 μCi of gamma emitting isotopes (e.g. ^{125}I) or high-energy beta emitters (e.g. ^{32}P)
- Experiments with ^{3}H, ^{14}C, ^{35}S, ^{33}P are permissible in quantities of less than 50 μCi per week.
- Contact the Office of Environmental Health & Radiation Safety for use of a radionuclide other than those listed above.
- Personal monitoring at RSO's discretion depending on activity levels and proximity of gamma emitters and high-energy beta emitters.
- The minor may not work alone.

Section IV. Appendix

IV. a. Process Summaries

Process Summaries

1.) Becoming an Authorized User

2.) Ordering Radioactive Material

3.) Receiving Radioactive Material

4.) Requesting a Personal Radiation Monitoring Badge

Becoming an Authorized User

Radiation Safety Process Summary

To become an authorized user, you must:

- Become familiar with applicable radiation safety requirements which can be found in the University Radiation Safety Manual.
- Meet the qualifications for an authorized user.
- Apply for authorization through the Radiation Safety Officer to the Radiation Safety Committee.
- Upon approval from the Radiation Safety Committee and before receiving a source of radiation, contact the Office of Environmental Health & Radiation Safety to set up your facility (e.g., posting and labeling) and a post approval interview.

Qualifications

Unless there are compelling reasons otherwise, Radiation Safety Committee will only approve faculty members as authorized users.

An authorized user must have previous experience working with radioactive materials which require similar radiation safety precautions. An individual does not need previous experience working with similar radioactive material to work with radioimmunoassay kits, or generally licensed radioactive material.

An inexperienced applicant may gain experience by one of the following methods. The Radiation Safety Officer / Committee will determine which is most appropriate.

- Perform dry run of proposed procedure under the review of the Radiation Safety Officer or designee.
- Perform a limited activity run of the proposed procedure.
- Perform the procedure under the supervision of an authorized user which has approval to perform the same procedures.

Applying for Authorization

Complete the Application for Possession and Use of Radioactive Materials in Basic Research and submit it to the Radiation Safety Officer. An unsigned electronic copy can be submitted for initial review, but a signed copy must be submitted for the records.

If more radioisotopes are needed than the application form provides for, then complete the Supplemental Sheet for Additional Isotopes or Chemical Forms and submit it along with the primary application.

If you will be administering radioactive materials to animals, then complete the Radioactive Materials in Laboratory Animals Questionnaire and submit it along with the primary application. Note that Institutional Animal Care and Use Committee approval will also be necessary for work involving animals.

The Radiation Safety Committee meets 4 times per year but conducts business between meetings by e-mail.

Ordering Radioactive Material

Radiation Safety Process Summary

Procuring radioactive materials is a simple 3-step process.

1.) Complete a standard request to purchase form (available from University Procurement). Include the isotope, chemical compound, and quantity along with all other standard information necessary to order the material (e.g., catalog number, account numbers). Do NOT use the University Purchasing Card to order radioactive material.
2.) Send the standard purchase requisition to the Radiation Safety Technical Staff Office.
    a. Fax the requisition to 215.895.5926 or e-mail a scanned copy of the requisition to radiationsafety@drexel.edu.
    b. Follow-up with a phone call to confirm receipt of the fax or e-mail, especially if receipt of the material is critical.
3.) Wait for approval.
    a. Radiation Safety reviews the purchase requisition to assure that the lab is authorized to possess the requested radioactive material.
    b. Radiation Safety faxes the approved purchase requisition to University Procurement.
    c. University Procurement reviews the purchase requisition to assure that funding is available, etc.
    d. University Procurement places the order.
    e. Radiation Safety receives notice of the order and tracking information for the package.
    f. Radiation Safety receives the package. (At Queen Lane and Main Campus, the package is received at the loading dock and is stored in a secure location. Radiation Safety is called and goes to the site to take possession of the package.)
    g. Radiation Safety checks the package for damage and for external contamination.
    h. Radiation Safety delivers the package to the laboratory.

Note: Every effort will be made to process the purchase requisition the same day it is received; however, requisitions received late in the business day may be processed the next business day.

Receiving Radioactive Material

Radiation Safety Process Summary

Radioactive materials are received initially by Radiation Safety. At Center City, the package is delivered by the carrier directly to the Radiation Safety Office. At Queen Lane and Main Campus, the package is delivered by the carrier to central receiving which secures the package and contacts Radiation Safety for handling.

Radiation Safety:

- Examines the package for signs of damage during shipping;
- Surveys the exterior of the package for contamination;
- Logs the package receipt; and
- Delivers the package to the laboratory.

Laboratory personnel are responsible for:

- Opening the package;
- Examining the contents for signs of damage or leakage;
- Confirming that the contents match what was ordered;
- Surveying packing material for contamination;
- Obliterating markings and labels on the packing material that include the radiation warning symbol or the word “radioactive”;
- Disposing of packing material;
- Documenting the above on the bottom portion of the Radioactive Material Receipt and Survey Form, forwarding a copy to Radiation Safety and retaining a copy of the form for inspection.

If a package is inadvertently received directly by the laboratory, contact Radiation Safety.

Requesting a Personal Radiation Monitoring Badge

Radiation Safety Process Summary

If you are using radioactive materials or radiation producing machines, please complete the Radiation Worker Registration form and submit it to the Office of Environmental Health & Radiation Safety. The Office of Environmental Health & Radiation Safety will use this to determine whether to provide radiation monitoring.

The institution is legally obligated to provide radiation monitors to individuals that are likely to exceed 10% of the occupational radiation exposure limits. The following table provides doses at which radiation monitoring is obligatory:

	Annual Dose Limit (mrem)	Monitoring Required (mrem)
Adult whole body	5,000	500
Extremity	50,000	5,000
Fetus (per gestation)	500	100
Minor whole body	500	100

Drexel University chooses to provide radiation monitoring at levels lower than required. The rule of thumb used is to monitor individuals that may receive measurable radiation doses. The following table provides guidance for radiation monitoring:

Low to moderate energy beta emitters: e.g., ^{3}H, ^{14}C, ^{35}S, ^{33}P, ^{45}Ca, ^{63}Ni	Radiation is too weak to be measured. No monitoring provided.
High energy beta emitters: e.g., ^{32}P, $^{90}Sr/^{90}Y$, ^{86}Rb	Manipulation of more than 1 mCi at any time. Extremity (finger/hand) monitoring.
Unshielded photon emitters	Manipulation of more than 0.1 mCi at any time. Whole body / extremity monitoring.
Open beam x-ray machines	Any operation of equipment unless behind shielded area. Extremity monitoring.
Enclosed beam x-ray machines	Shielding provided by enclosure. No monitoring provided.
Devices containing radioactivity	Determined on a case-by-case basis.

Section IV. Appendix

IV. b. Forms

Forms

Index

Form Title

- **Radiation Worker Registration**
- **Application for Possession and Use of Radioactive Materials in Basic Research**
- **Application for Possession and Use of Radioactive Materials in Basic Research – Supplemental Sheet for Additional Isotopes or Chemical Forms**
- **Application for Possession and Use of Radioactive Materials in Basic Research – Supplement for Laboratory Animal Uses**
- **Amendment to Existing Authorization for Use of Radioactive Materials**
- **Declaration of Pregnancy**
- **Radioactive Material Receipt and Survey Form**
- **Laboratory Survey Report Form**
- **Sink Disposal of Radioactive Material Log**
- **Radiation Emergency Instructions**
- **Quarterly Radionuclide Inventory and New Staffing Report**
- **Radiation Safety Orientation Form**

Audit Forms used by the Office of Environmental Health & Radiation Safety for information only

- **Analytical X-ray Unit Audit and Survey Form**
- **Cabinet X-ray Unit Audit and Survey Form**
- **Electron Microscope Survey and Audit Form**
- **Non-medical / Non-veterinary Radiographic X-ray Unit Audit and Survey Form**
- **Laboratory Audit Results**

Notes:

1.) **Forms available for downloading with fill-in fields may have minor formatting differences from the forms in this Manual.**
2.) **Contact the Office of Environmental Health & Radiation Safety for the most recent version of these forms.**

DREXEL UNIVERSITY
RADIATION WORKER REGISTRATION

Identification		
Name: First MI Last		**Gender:**
Last 4 digits of SSN:	**Birthdate:** / /	**Title/Position:**
Email:	**Phone:**	**Fax:**

Location		
Department:		**Supervisor/PI:**
Employer: ☐ Drexel University ☐ Drexel College of Medicine	☐ St. Christopher's Hospital ☐ Other:	
Campus:	**Building:**	**Room:**

Involvement With Radiation Sources						
☐ Unsealed radioactive material	Isotope	mCi	Isotope	mCi	Isotope	mCi
☐ Unsealed radioactive material	Isotope	mCi	Isotope	mCi	Isotope	mCi
☐ Device containing radioactive sources ☐ Irradiator ☐ HDR ☐ Other:						
☐ X-ray producing machine(s) ☐SEM ☐TEM ☐XRD ☐Radiographic ☐Fluro ☐CT ☐Linac						
☐ Frequent area where source is used or assist others directly handling/using source	Describe source:					

Training – List radiation safety training courses attended		
Date:	Provider:	Course:
Date:	Provider:	Course:
Date:	Provider:	Course:

Experience – Check all that best describe your experience with sources of radiation				
☐Sealed sources	☐^{60}Co, ^{137}Cs, ^{192}Ir	☐^{125}I, ^{103}Pd, ^{90}Sr	☐ Irradiator /shielded device	☐Radiography
☐Unsealed sources	☐^{32}P, ^{51}Cr, ^{22}Na, ^{86}Rb	☐^{99m}Tc, ^{123}I	☐ Linear Accelerator	☐Fluoroscopy
☐Research lab	☐^{14}C, ^{3}H, ^{35}S, ^{45}Ca	☐^{18}F PET	☐ Electron microscope	☐ < 1 mCi
☐Clinical uses	☐^{131}I, ^{89}Sr, ^{153}Sm, ^{90}Y	☐Check sources	☐ X-ray diffraction	☐ > 1 mCi

Radiation Exposure (current year only)				
☐Received radiation dose	Whole Body: mrem	Skin: mrem	Eye: mrem	Finger: mrem
Organization:		Contact Info:		
☐Did not receive radiation dose				
Signature: _____	Date: _____	☐ Name and date entry act as signature		

RSO Use Only						
Initial Badge Assignment						
Issue Date:	Wear Date:	Badge No:	Location:	Type:		
Permanent Badge Assignment						
☐ Monthly ☐ Bimonthly ☐ Quarterly	☐ Body ☐ Collar ☐ Waist	☐ Ring ☐ Fetal ☐ Other:	Facility:	Location:	Participant No:	Date Issued:

DREXEL UNIVERSITY

Application for Possession and Use of Radioactive Materials in Basic Research

Identification			
Name: First	MI	Last	Suffix Degree (MD. PhD)
Department:		**Faculty Appointment:**	
Email:	**Phone:**		**Fax:**

Location	
Employer: ☐ Drexel University ☐ Drexel College of Medicine	Campus: ☐ Center City ☐ Queen Lane ☐ University City ☐ Other:
Office: Building	Room

Radioactive Material			
Radionuclide 1:	Chemical Form:		
Physical Form: ☐ gas ☐ liquid ☐ sealed source ☐ plated source ☐ other solid			
	For sealed or plated source:	Mfg/model:	Device mfg/model:
	For other solid, describe source (e.g., powder, activated metal):		
Activity per order: µCi	Order frequency: per week		
Activity per experiment: µCi	Experiment frequency: per day		
Maximum amount in lab at one time (including in waste): µCi			
Radionuclide 2:	Chemical Form:		
Physical Form: ☐ gas ☐ liquid ☐ sealed source ☐ plated source ☐ other solid			
	For sealed or plated source:	Mfg/model:	Device mfg/model:
	For other solid, describe source (e.g., powder, activated metal):		
Activity per order: µCi	Order frequency: per week		
Activity per experiment: µCi	Experiment frequency: per day		
Maximum amount in lab at one time (including in waste): µCi			
Radionuclide 3:	Chemical Form:		
Physical Form: ☐ gas ☐ liquid ☐ sealed source ☐ plated source ☐ other solid			
	For sealed or plated source:	Mfg/model:	Device mfg/model:
	For other solid, describe source (e.g., powder, activated metal):		
Activity per order: µCi	Order frequency: per week		
Activity per experiment: µCi	Experiment frequency: per day		
Maximum amount in lab at one time (including in waste): µCi			

Methods/Procedures

Describe the laboratory procedures performed with radioactive materials. (Reprint may be attached if it describes the methods in detail)

Radioisotope 1:

Have you performed these procedures previously: ☐ yes ☐ no

Radioisotope 2:

Have you performed these procedures previously: ☐ yes ☐ no

Radioisotope 3:

Have you performed these procedures previously: ☐ yes ☐ no

If these procedures involve administration of radioactive material to animals, complete the Animal Use Questionnaire. If you are applying for additional isotopes or additional chemical forms, complete the supplemental isotope form (a simplified copy of this page). Very similar chemical forms can be grouped together (e.g., nucleotide triphosphates).

Equipment and Facilities

Location (List building(s) and room (s) where radioactive material will be used or stored, and the room use)

Campus	Building	Room No.	Use

Analytical Radiation Detection Equipment (List the type, manufacturer, model number, and location of any analytical equipment used with this protocol)

Type	Mfg & Model No.	Location

Manufacturer & Model No.	Instrument/Probe Type

Describe available shielding:

Hood(s):		

Radioactive Waste

Indicate the types of waste and the disposal category that will be generated

	Solid	Aqueous Liquid	Organic Liquid	Liquid Scintillation Fluid (flammable)	Liquid Scintillation Fluid (nonflammable)	Animal Carcasses	Sealed Sources
Decay-in-Storage (Half-life < 30 days)	☐	☐	☐		☐	☐	
Storage for Decay (Half-life < 100 days)	☐	☐	☐		☐	☐	☐
Sewer Disposal		☐	☐		☐		
Exempt biomedical				☐	☐	☐	
Mixed Waste (Hazardous & radioactive)	☐	☐	☐		☐	☐	
Off-Site Disposal	☐		☐	☐	☐	☐	☐

Estimate the volume of waste generated annually:

Solids & liquids stored for decay: Liters

Off-site disposal: small (5 gal, 0.7 cf)	Liquid scintillation fluid: small (5 gal, 0.7 cf) pails
Animal carcasses: cubic feet	Mixed waste Liters

By activity, estimate the amount of waste to be sewer disposed per month: µCi

Training and Experience

Complete this section if you do not currently have approval to use radioactive materials at Drexel University or the College of Medicine

Formal and On-the-Job Training

Topics	Institution(s) where training was received	Dates of Training	Instruction Hours (Lab & Classroom)
Principles of radiation protection			
Measurement/monitoring techniques and instruments			
Calculations applicable to radioactivity (e.g., half-life decay)			
Biological effects of radiation			

Personal Experience with Radioactive Materials

Radionuclides	Maximum amounts handled (mCi)	Institution(s) where experience was gained	Duration of experience	Type of use

Have you ever been an authorized user? ☐ yes ☐ no If so, where? _____

Laboratory Personnel

List *other* personnel who will be working with radioactive materials under your authorization.

Name	Registered as a Radiation Worker	Initial radiation safety instructions provided by PI	Attended Radiation Safety Short Course
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐

Certification

I agree to conduct activities under this authorization in full compliance with applicable federal, state, and local regulations, and institutional policies. I have read and understand the applicable parts of the Radiation Safety Manual and agree to keep an updated Manual on file for reference in my office or laboratory. I understand and agree that it is my responsibility to post requisite signs, labels, and warnings prominently in my laboratory; to perform and document wipe tests for removable contamination after each experiment; to train or provide training for all radioactive material users under my supervision; to account for the receipt, use, and disposal of all radioactive materials; and to properly dispose of radioactive materials. I agree to contact the Radiation Safety Officer before transferring radioactive materials, before moving into or out of laboratories, and in the event of a spill or incident or emergency involving radioactive materials.

Signature: _____ Date: _____ ☐ Name and date entry act as signature

DREXEL UNIVERSITY

Application for Possession and Use of Radioactive Materials in Basic Research – Supplemental Sheet for Additional Isotopes or Chemical Forms

Identification				
Name:	First	MI	Last	Suffix

Radioactive Material			
Radionuclide 1:	Chemical Form:		
Physical Form: ☐ gas ☐ liquid ☐ sealed source ☐ plated source ☐ other solid			
For sealed or plated source: Mfg/model:		Device mfg/model:	
For other solid, describe source (e.g., powder, activated metal):			
Activity per order: µCi	Order frequency: per week		
Activity per experiment: µCi	Experiment frequency: per day		
Maximum amount in lab at one time (including in waste): µCi			
Describe the laboratory procedures.			
Have you performed these procedures previously? ☐ yes ☐no			

Radionuclide 2:	Chemical Form:
Physical Form: ☐ gas ☐ liquid ☐ sealed source ☐ plated source ☐ other solid	
For sealed or plated source: Mfg/model:	Device mfg/model:
For other solid, describe source (e.g., powder, activated metal):	
Activity per order: µCi	Order frequency: per week
Activity per experiment: µCi	Experiment frequency: per day
Maximum amount in lab at one time (including in waste): µCi	
Describe the laboratory procedures.	
Have you performed these procedures previously? ☐ yes ☐no	

If these procedures involve administration of radioactive material to animals, complete the Animal Use Questionnaire.

Signature: _____ Date: _____ ☐ Name and date entry act as signature

DREXEL UNIVERSITY

Application for Possession and Use of Radioactive Materials in Basic Research – Supplement for Laboratory Animal Uses

Authorized User Identification				
Name:	First	MI	Last	Suffix

Radioactive Material Type and Quantity	
Radionuclide:	Chemical compound:
Activity administered per animal: μCi	
Number of animals administered radioactive material:	Number of administrations per animal:

Administration to Animals
Animal species (e.g., rat, mouse):
Describe administration method:
Will animals be anesthetized for administration? ☐ yes ☐ no
If no, how will animals be restrained for administration?

Biodistribution, Metabolism, Elimination	
Which of the following are likely to be radioactive? (check all that apply)	☐ Sweat/skin oils ☐ Urine ☐ Feces ☐ Saliva/venom ☐ Blood or other circulating system fluid
In which organ or tissue is the radioactivity likely to accumulate or concentrate?	
Briefly describe the expected pharmacokinetics	

Will the animals be euthanized? ☐ yes ☐ no

If yes, how? _____

How long will animals survive after administration? _____ minutes

How will carcasses be disposed? _____

Locations

Where will administration occur?

☐ Animal facility, specifically (e.g., cage room, surgical suite): _____

☐ My laboratory

☐ Other (describe arrangements): _____

Will animals remain at this location until euthanasia? ☐ yes ☐ no ☐ animals will not be euthanized

If no, how long will animals remain at this location before returning to animal facility? _____

Animals will be moved to: ☐ Animal facility ☐ Other: _____

How much radioactive material will remain in each animal when moved? _____ μCi

Animal Care and Precautions

Who will care for animals after administration? ☐ Animal facility staff ☐ Lab staff ☐ n/a (animals euthanized)

If lab staff, describe weekend/holiday arrangements for animal care:

How will these animals be identified as radioactive?

What types of cages will be used (e.g., metabolic, disposable)?

Describe procedures cleaning / decontaminating cages:

Describe procedures for surveying cages prior to returning them for general use:

Describe procedures for removal of potentially radioactive bedding, leftover food, etc.:

Describe special precautions necessary to care for these animals:

Describe procedure for surveying and decontaminating animal housing area for release to unrestricted use:

Describe arrangements to train animal caretakers regarding radioactive hazards associated with this project:

In case of animal bite, personnel know to instruct medical personnel that wound may be radioactive: ☐ yes ☐ no

In case of animal bite, personnel know to contact or have someone contact the RSO immediately: ☐ yes ☐ no

Institutional Animal Care and Use Committee Status

What is the status of the IACUC approval?

- ☐ Not submitted
- ☐ Submitted, pending committee action
- ☐ Approved pending EHRS approval
- ☐ Approved with pending conditions
- ☐ Rejected

Signature: _____ Date: _____ ☐ Name and date entry act as signature

DREXEL UNIVERSITY

Amendment to Existing Authorization for Use of Radioactive Materials

Authorized User Identification

Name: First MI Last Suffix

I request that my authorization to use radioactive materials be amended as indicated below:

1. Add new isotope(s) or chemical form(s) *(also complete Section 4)*

(a) Isotope: _____ Activity: _____ mCi

Chemical Form: _____

Sink disposal limit for above isotope (default is 10% of possession limit): _____

(b) Isotope: _____ Activity: _____ mCi

Chemical Form: _____

Sink disposal limit for above isotope (default is 10% of possession limit): _____

2. Possession Limits Change *(provide reason for increase in Section 4)*

Isotope: _____ Current Limit: _____ Proposed Limit: _____

Isotope: _____ Current Limit: _____ Proposed Limit: _____

Isotope: _____ Current Limit: _____ Proposed Limit: _____

3. Sink Disposal Limit Change *(provide reason for increase in Section 4)*

Isotope: _____ Current Limit: _____ Proposed Limit: _____

Isotope: _____ Current Limit: _____ Proposed Limit: _____

Isotope: _____ Current Limit: _____ Proposed Limit: _____

4. New Procedure

Describe specific procedures proposed.

Specific radiation safety steps to be taken, include description of additional waste generated.

Signature: _____ Date: _____ ☐ Name and date entry act as signature

CONFIDENTIAL

Declaration of Pregnancy

To: Radiation Safety Officer

From: _____

Subject: **Declaration of Pregnancy**

Date: _____

Pursuant to regulatory requirements and Drexel University / Drexel University College of Medicine policy, I have been informed of my pregnancy rights and am declaring my pregnancy. I understand that by declaring my pregnancy, a dose limit of 5 mSv/term (500 millirem/term) to the embryo/fetus (10% of the annual radiation exposure limit to a radiation worder) is imposed. I also understand that the institution may require enhanced engineering controls, administrative controls, additional personal protective equipment, and/or additional monitoring to assure compliance with the dose limits.

I certify that I am making this declaration voluntarily.

The estimated date of conception (month/year) is _____.

Signature: _____

Name Printed: _____

Date Signed: _____

For Environmental Health & Radiation Safety Office Use Only

Dose registered to date: _____mR

Action taken:

_____

_____

_____

_____

_____

_____

Department of Environmental Health & Radiation Safety

Radiation Safety Office
New College Building, Rm 12135
245 N. 15th St / Mailstop 106
Philadelphia, PA 19102

Office Phone: 267-359-2606
Technician Cell: 215-203-6733

Order

Authorized User:	Authorization Number:	Phone:
Authorized User Location (Room and Building):		
Isotope:	Activity: ☐ µCi ☐ mCi	Compound:
Vendor:	Catalog Number:	Purchase Order Number:

Package Receipt

Date Received:	Package ID Number:	Isotope and activity are consistent with order: ☐ yes ☐ no
Package Condition: ☐ No Damage ☐ Crushed ☐ Punctured ☐Wet ☐ Other: _____		
If damaged: 1) monitor for contamination and radiation levels, and 2.) contact the Radiation Safety Officer immediately		

External Wipe Survey

Labeling: ☐ No Label ☐ Radioactive White I ☐ Radioactive Yellow II ☐ Radioactive Yellow III

If labeled: wipe all external surfaces (at least 300 cm^2) with a filter paper; count in appropriate counter; calculate activity.

(1) Counting Instrument:	(2) Wipe (cpm)	(3) Background (cpm)	(4) Net cpm (2) – (3)	(5) Efficiency	(6) dpm (4) / (5)	(7) Area Wiped	(8) dpm per 100 cm^2 [(6)/(7)] × 100

******If removable activity exceeds 2200 dpm/100 cm^2, contact the Radiation Safety Officer, immediately. ******

If not labeled: wipe all external surfacds and check for gross removable contamination with GM or other survey meter.

☐ No removable activity detected ☐ Removable activity detected – contact the Radiation Safety Officer

Radiation Level Survey – Optional (except for multi-Curie sources)

Radiation level 3 feet from the package: mR/hour	Radiation level on package surface: mR/hour

Package Delivery to Laboratory

Package Received By:		Date Received:	

Instructions: Complete internal package survey and indicate the final disposition of the package and packing material below. Fax the completed form to the Radiation Safety Office at 267-359-2793.

Internal Package Survey

Packing slip and vial contents are consistent:	Radionuclide	Activity	Chemical	Vial integrity intact
	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
If any answer is no, contact the Radiation Safety Officer				

Disposition of Package / Packing Material

☐ Package and packing material free of contamination (< 200 dpm/100 cm^2), labels obliterated, and disposed as regular trash.	☐ Package or packing material contaminated, disposed as radioactive waste	☐ Package or packing material free of contamination and returned to supplier

Laboratory Survey Report Form

Authorized User: _____ Location (building/room): _____

Survey Date: _____ Radionuclides used during period: _____

Area Survey

Using a radiation detection survey meter, measure general radiation levels and spots of contamination.

Location(s) (describe or indicate on sketch)	Dose Rate (mR/hr)	Background (mR/hr)
1.		
2.		
3.		
4.		
5.		

Survey Instrument Used	
Mfg.	
Model No.	
Serial No.	
Probe Type	
Calibration Date	

Wipe Survey

Wipe possibly contaminated surfaces with a filter paper or cotton swab. Include items/areas where radioactive materials are not used but users of radioactive material congregate (e.g., telephones, lunchroom). For beta emitting radionuclides, count the wipe samples in a liquid scintillation counter. For photon emitting radionuclides, count the wipe samples in a gamma counter, e.g. a well counter.

[1] Location(s) (describe or indicate on sketch)	[2] Instrument (ID)	[3] Wipe (cpm)	[4] Bkg (cpm)	[5] Net cpm [3]-[4]	[6] Eff.	[7] dpm [5]/[6]	[8] Area Wiped (cm^2)	[9] dpm/100 cm^2 [[7]/[8]] x 100
A.								
B.								
C.								
D.								
E.								

Instrument ID	A Gamma Counter	B Liquid Scintillation Counter
Mfg.		
Model No.		
Serial No.		

This form to be retained in your files. Call the Radiation Safety Office if contamination>1000 dpm/100 cm^2 or if unexpected radiation levels (e.g., >2 mR/h in unrestricted areas) are found.

Room Diagram

Signature: _____ Date: _____

Notes:

1. Above surveys to be performed after completion of experiment or no less than monthly.
2. Area survey necessary only if handling gamma and high-energy beta emitters.
3. For wipe test surveys a copy of counter print out indicating dpm in lieu of table above is acceptable.

Authorized User: _____ Building: _____

Lab or Room #: _____ Calendar Qtr. _____ Year: _____

Sink Disposal of Radioactive Material Log

Isotope: _____ Limit: _____ μCi / month

Isotope: _____ Limit: _____ μCi / month

Isotope: _____ Limit: _____ μCi / month

Isotope: _____ Limit: _____ μCi / month

- Radioactive materials disposed down the sink **must be readily soluble in water** or be biologically dispersible material.
- Pour liquid directly down drain to avoid contaminating sink.
- Run water after sink disposal to eliminate radioactive material standing in drain pipes.

Date	Isotope	Amount	Initials

Send this form in with the quarterly inventory report.

Radiation Emergency Instructions

MINOR SPILLS involving no radiation hazard to personnel.

1. **Notify** all other personnel in the area where the spill occurred.
2. **Prevent the spread of contamination** by covering the spill with absorbent paper.
3. **Decontaminate** the area, using paper towels to clean the spill starting from the outside and moving toward the center. Place all waste into plastic bags and dispose of it as radioactive waste. Disposable gloves, lab coats, and shoe covers should be worn. Cleansing agents may be used after an initial decontamination attempt using a radiation decontaminant.
4. **Survey** the area and all contaminated and potentially contaminated individuals with a G-M survey meter. Survey for removable contamination using wipe samples.
5. **Report** the incident to the Office of Environmental Health & Radiation Safety by telephone.

MAJOR SPILLS involving potential radiation hazard to personnel, involving personal contamination, involving actual or potential uptake of radioactive material, or which threatens to restrict the use of the facility.

1. **Clear the area**: notify all persons not involved with or near the spill to vacate the room.
2. **Prevent the spread of contamination**: cover the spill with absorbent paper. Do NOT attempt to clean it up. Assemble all potentially contaminated personnel near the room entrance.
3. **Close the room**: Assemble all potentially contaminated personnel near the room entrance. Close and prevent entry into the room.
4. **Call for help**: Immediately contact EHRS at (215) 895-5919
5. **Survey**: Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by EHRS. Contaminated skin should be flushed thoroughly and then washed with mild soap and lukewarm water.

FIRES

1. Rescue people in immediate danger.
2. Alarm – activate a manual pull station / fire box and call the Public Safety 24-Hour Call Center at (215) 895-2222. Notify the dispatcher of the precise location of the fire.
3. Confine the smoke and fire by closing all doors and windows. Shut off the piped and compressed gas as you evacuate.
4. Evacuate the area / building.

Only attempt to extinguish a fire if you have been trained in the proper use of an extinguisher. Only small fires can be extinguished; always be prepared to evacuate

Do NOT attempt to extinguish the fire if radioactive materials are directly involved. Evacuate the area, contact Radiation Safety, and notify the firefighters of the radioactive materials that are involved.

During normal working hours, Environmental Health & Radiation Safety can be reached at the following numbers:

Main Number: (215) 895-5919 **Radiation Safety Officer**: (215) 669-6122

Radiation Safety Technician: (215) 203-6733

After hours, call the Drexel 24-hour call center at (215) 895-2222 and ask for Radiation Safety.

Quarterly Radionuclide Inventory and New Staffing Report

Authorized User: | Reporting Period: ☐ 1st Quarter 1/1 - 3/31 ☐ 2nd Quarter 4/1 - 6/30 ☐ 3rd Quarter 7/1 - 9/30 ☐ 4th Quarter 10/1 - 12/31 | Year 20

The table below was completed using units of: ☐ millicuries (mCi) or ☐ microcuries (μCi).
If additional columns are needed for more radionuclides, attach a second form.

Radionuclide(s)					
Activity on hand at beginning of quarter					
Activity received during quarter	+	+	+	+	+
Activity transferred to others during quarter*	-	-	-	-	-
Activity given to Radiation Safety as waste	-	-	-	-	-
Activity disposed down drain	-	-	-	-	-
Other:	-	-	-	-	-
Decay losses**	-	-	-	-	-
Balance on hand at end of quarter					
Possession Limit					

*All transfers to be approved via submission of RSO Form 1.8A.

Indicate all new personnel that have started working under your authorization during the quarter.

	RSO Use Only	
Name	Registered	Training

Note: All new personnel must be oriented to the laboratory and the use of radioactive materials (use RSO Form 2.6A) before handling radioactive materials. Please send a completed copy of Form 2.6A with this inventory. These are all in addition to attendance at the Radiation Safety Short Course.

**Decay losses can be calculated as follows:

Decay Loss $= A_o\left(1 - e^{-\left(\frac{0.693(t)}{\text{half-life}}\right)}\right)$ **where A_o is the initial activity, and t is the elapse time in the same units as half-life.**

Radiation Safety Orientation Form

This form is to be utilized during the orientation of research laboratory personnel during their formal orientation on site. Please send a copy to the Radiation Safety Office and file the original

Name: _____ (First Last)

Title: _____ (e.g., student, lab tech, post doc, asst. prof)

Authorized User: _____

Department: _____

Date of Orientation: _____

Topics to be covered during orientation:

- ☐ Location and review of all radiation safety documents including authorization and procedure manuals (including conditions of authorization).
- ☐ Procedure for ordering radioactive materials.
- ☐ Proper use of survey meters.
- ☐ Proper use and location of all safety equipment.
- ☐ Proper use and quality control of radiation measuring or assay equipment.
- ☐ Proper procedure for wipe tests and department surveys. Review of all trigger levels. Recording results in dpm/100cm^2.
- ☐ Proper spill and cleanup procedure and notification of the Radiation Safety Officer.
- ☐ Proper waste management of radioactive materials.
- ☐ Proper security for restricted areas.
- ☐ Proper personnel monitoring.
- ☐ Medical emergency procedures.
- ☐ Pregnancy exposure procedures.
- ☐ Tour of specific work area.

I certify that I have instructed the above-named individual in the topics listed above as they relate to work in our laboratory. I am available to this person for additional information or support.

_____ _____

Signature of Person Performing Orientation Date

I certify that I have received the radiation safety instructions outlined above. I understand that if I have any questions or concerns that I may contact the Radiation Safety Officer at any time.

_____ _____

Signature Date

Note: The above does not replace the periodic short course given by the Radiation Safety Office which is required of all individuals that have not received formal training elsewhere.

RSO Review: _____ _____

Signature Date

Audit Forms

Used by Environmental Health & Radiation Safety

For Information Only

Department of Environmental Health & Radiation Safety

Analytical X-ray Unit Audit and Survey Form

Responsible Individual: _____ Audit Date: _____

Location: Room: _____ Building: _____ Campus: _____

Make: _____ Model: _____ Unit S/N: _____

Configuration: _____ Brief description of use: _____

	General Requirements for Analytical X-ray Units		**Yes**	**No**	**n/a**
1	Warning devices are labeled so that their purpose is easily identified.	[§§227.11a(c)]	☐	☐	☐
2	Equipment has fail-safe characteristics.	[§§227.11a(c)]	☐	☐	☐
3	An easily visible warning light located immediately adjacent to the tube head or port and labeled with the words "X-ray on" or words containing a similar warning, is provided and is illuminated when the X-ray tube is energized	[§§227.11a(d)]	☐	☐	☐
4	Unused ports on radiation source housings shall be secured in the closed position in a manner which will prevent casual opening	[§§227.11a(e)]	☐	☐	☐
5	Unit is labeled with a readily discernible sign bearing the radiation trefoil symbol and (a) *"Caution – High Intensity X-Ray Beam"* or similar wording on the X-ray source housing, and (b) *"Caution Radiation – This Equipment Produces Radiation When Energized"* or similar wording, near any switch that energizes an X-ray tube.	[§§227.11a(f)]	☐ ☐	☐ ☐	☐ ☐
6	Safety and warning devices (e.g., interlocks, warning lights) operate properly Device: _____ Test: _____ Device: _____ Test: _____ Device: _____ Test: _____ Device: _____ Test: _____ Device: _____ Test: _____ Device: _____ Test: _____	[§§227.12a(e)]	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐
7	Unit was taken out of service due to a malfunctioning safety or warning device	[§§227.12a(e)]	☐	☐	☐

Radiation Levels and Surveys

8	The leakage radiation is less than 2.5 mR/hour at 5 cm from the surface of the source housing when all the shutters are closed. Radiation Detector used: Mfg: _____ S/N: _____ Cal. Date: _____ Location: _____ Dose rate: _____mR/h Location: _____ Dose rate: _____mR/h Location: _____ Dose rate: _____mR/h Location: _____ Dose rate: _____mR/h	[§§227.12a(e)]	☐	☐	☐
9	The leakage radiation is less than 0.5 mR/hour at 5 cm from the surface of the x-ray generator housing. Location: _____ Dose rate: _____mR/h Location: _____ Dose rate: _____mR/h Location: _____ Dose rate: _____mR/h	[§§227.12a(b)]	☐	☐	☐
10	Radiation Levels in any area surrounding local components will not result in a dose to an individual over 100 mrem Location: _____ Dose rate: _____mR/h Location: _____ Dose rate: _____mR/h	[§§227.12a(c)]	☐	☐	☐

			Yes	No	n/a
11		Surveys are performed:			
		(a) annually	☐	☐	☐
		(b) Follow a change in the initial arrangement, number or type of local components*	☐	☐	☐
		(c) Following maintenance requiring the disassembly or removal of a local component*	☐	☐	☐
		(d) During the performance of maintenance and alignment procedures that require the presence of a primary X-ray beam when a local component* in the system is disassembled or removed	☐	☐	☐
		(e) When a visual inspection of the local components* reveals an abnormal condition	☐	☐	☐
		(f) When personnel monitoring devices show a significant increase in radiation exposure over the previous monitoring period or the readings are approaching the radiation dose limits	☐	☐	☐
		(g) When the machine is operated in a manner other than the routine manner specified in the operating procedures.	☐	☐	☐
		*local component means parts of an analytical X-ray system, such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding, that contain or are in the path of the X-ray beam. The term does not include power supples, transformers, amplifiers, readout devices, and control panels			

Training and Monitoring		Yes	No	n/a
18	Individuals operating or maintaining the unit have received instructions in and demonstrated competence as to:			
	(a) Identification of radiation hazards associated with the use of the equipment.	☐	☐	☐
	(b) Significance of the various radiation warning and safety devices incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment, and the extra precautions necessary if the devices are absent or bypassed.	☐	☐	☐
	(c) Written operating and emergency procedures for the equipment.	☐	☐	☐
	(d) Symptoms of an acute localized radiation exposure.	☐	☐	☐
	(e) Procedures for reporting an actual or suspected exposure.	☐	☐	☐
	(f) Use of survey and personnel monitoring equipment.	☐	☐	☐
	(g) The applicable regulations of this article and those incorporated by reference. [§§227.14(a)]	☐	☐	☐
19	Finger or wrist personnel monitoring devices have been provided to and are used by personnel maintaining analytical X-ray equipment if the maintenance procedures require the presence of a primary X-ray beam when a local component in the analytical X-ray system is disassembled or removed or when safety devices are bypassed. [§§227.13a(b)]	☐	☐	☐
20	A qualified expert has reviewed reported dose values for the purpose of determining compliance with 10 CFR 20.1201. [§§227.13a(c)]	☐	☐	☐
Special Requirements for Open Beam Systems				
21	Unit has a safety device which prevents entry of any portion of an individual's body into the primary X-ray beam path, or causes the beam to be terminated or interrupted upon entry into the path. [§§227.11a(a)]	☐	☐	☐
22	If no, has an exemption from the requirement of a safety device been granted? [§§227.11a(a)]	☐	☐	☐
23	A readily discernible indication of:			
	(a) X-ray tube status (on-off) located near the radiation source housing (if the primary beam is controlled in this manner) and/or	☐	☐	☐
	(b) Shutter status (open-closed) located near each port on the radiation source housing (if the primary beam is controlled in this manner). [§§227.11a(b)]	☐	☐	☐
24	Finger or wrist personnel monitoring devices have been provided to and are used by analytical x-ray equipment workers using systems having an open-beam configuration and not shielded such that the worker would receive less than 100 mR. [§§227.13a(b)]	☐	☐	☐
25	Each port on the radiation source housing is equipped with a shutter that cannot be opened unless a collimator or coupling has been connected to the port. [§§227.11a(g)]	☐	☐	☐

Comments:

Audit performed by: _____

Reviewed by: _____

Jon M. Chase, M.S.
Radiation Safety Officer

Cabinet X-ray Units
Audit and Survey Form

Responsible Individual: _____ Audit Date: _____

Location: Room: _____ Building: _____ Campus: _____

Make: _____ Model: _____ Unit S/N: _____

Brief description of use: _____

		Yes	No	n/a
1	Exposure rate from the cabinet x-ray system is less than 0.5 mR/h five centimeters outside the external surface Compliance with the exposure limit shall be determined: (a) by measurements averaged over10 cm2 with no linear dimension greater than 5 cm, (b) with the cabinet x-ray system operated at those combinations of x-ray tube potential, current, beam orientation, and conditions of scatter radiation which produce the maximum x-ray exposure at the external surface, (c) and with the door and access panel fully closed as well as fixed at any other position which will allow the generation of x rays Location: _____ Dose rate: _____ mR/h Location: _____ Dose rate: _____ mR/h Location: _____ Dose rate: _____ mR/h Location: _____ Dose rate: _____ mR/h Location: _____ Dose rate: _____ mR/h Survey meter used: Mfg: _____ s/n: _____ Cal. Date: _____ [21 CFR 1020.40(c)]	☐	☐	☐
2	The insertion of any part of the human body through any port or aperture into the primary beam is not possible. §§1020.40(c)(3)	☐	☐	☐
3	Each door has at least two safety interlocks. (a) One, but not both, disconnects the energy supply circuit to the high-voltage generator when door opens. (b) The interlock is not dependent upon any moving part other than the door. §§1020.40(c)(4)(i)	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
4	Each access panel has at least one safety interlock §§1020.40(c)(4)(ii)	☐	☐	☐
5	A control must be activated to resume x-ray generation following interruption by an interlock §§1020.40(c)(4)(iii)	☐	☐	☐
6	Failure of any single component of the cabinet x-ray system does not cause failure of more than one required safety interlock. §§1020.40(c)(4)(iv)	☐	☐	☐
7	X-ray generation is not possible when the key to the key-actuated control is removed §§1020.40(c)(6)(i	☐	☐	☐
8	The unit has a control to initiate and terminate x-ray generation other than the safety interlocks or the main power control. §§1020.40(c)(6)(ii)	☐	☐	☐
9	(a) Two independent means indicate when and only when x-rays are being generated (b) Discernible from any point at which initiation of x-ray generation is possible. (c) Failure of a component of the cabinet x-ray system will not cause failure of both indicators (d) One indicator may be a milliammeter labeled to indicate x-ray tube current. (e) All other indicators legibly labeled "X-RAY ON" (f) One "X-RAY ON" indicator is visible from each door, access panel, and port §§1020.40(c)(6)(iii)	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐
10	A clearly legible and visible label bearing the statement: "Caution: X-Rays Produced When Energized" is permanently affixed or inscribed at the controls §§1020.40(c)(8)(i)	☐	☐	☐
11	A clearly legible and visible label bearing the statement: "Caution: Do Not Insert Any Part of the Body When System is Energized—X-ray Hazard" is permanently affixed or inscribed on the cabinet x-ray system adjacent to each port. §§1020.40(c)(8)(ii)	☐	☐	☐
12	Manufacturer's operating manual(s) and instructions are available. §§1020.40(c)(9)	☐	☐	☐

		Yes	No	n/a
13	The system does not exceed the limits in 10 CFR 20.1301 (relating to dose limits for individual members of the public – 100 mrem/year). 25 PA Code 225.100(b)	☐	☐	☐
14	(a) Individuals permitted to operate a cabinet X-ray system have received a copy of, and instruction in, the operating procedures for the X-ray system (b) Competency in the use of the cabinet X-ray system and an understanding of the operating procedures has been demonstrated. 25 PA Code 225.100(c)	☐ ☐	☐ ☐	☐ ☐
15	On-off switches, interlocks and safety devices are tested at intervals not exceeding 1 year Device: _____ Test: _____ Device: _____ Test: _____ Device: _____ Test: _____ Device: _____ Test: _____ Device: _____ Test: _____ 25 PA Code 225.100(e)	☐	☐	☐
Comments:				

Audit performed by: _____

Reviewed by: _____
Jon M. Chase, M.S.
Radiation Safety Officer

Electron Microscope
Survey and Audit Form

Responsible Individual: _____ Survey/Audit Date: _____

Location: Room: _____ Building: _____ Location: _____

Make: _____ Model: _____ Unit S/N: _____

Type: ☐ Scanning ☐ Transmission

		Yes	No
1	Radiation levels measured 5 centimeters from accessible surfaces of the electron microscope did not exceed 0.5 mR/h. (25 PA Code 227.32) Background reading: _____ mR/h Measured radiation level _____ mR/h Electron microscope settings: _____ kV _____ mA Other: _____ Radiation detector used: Mfg: _____ s/n: _____ Cal. Date: _____	☐	☐
2	Electron microscope is labeled with a readily discernable sign bearing the words, ''Caution Radiation—This Equipment Produces Radiation When Energized,'' or words containing a similar warning. (25 PA Code 227.31)	☐	☐
3	Operators have been trained and understand the operating procedures necessary to insure radiation safety. (25 PA Code 227.33)	☐	☐
4	Operators have received a copy of the operating procedures. (25 PA Code 227.33)	☐	☐

Comments:

Audit performed by: _____

Reviewed by: _____
Jon M. Chase, M.S.
Radiation Safety Officer

Non-medical / Non-veterinary Radiographic X-ray Unit
Audit and Survey Form

Responsible Individual: _____ Survey / Audit Date: _____

Location: Room: _____ Building: _____ Campus: _____

Address (if not on campus): _____

Unit Manufacturer: _____ Model: _____ s/n: _____

Tube Manufacturer: _____ Model _____ s/n _____

Brief description of use:

Layout Description:

Scatter Measurements (1 meter from central ray, 90° scatter)

Technique Factors used:

High Voltage (kVp)	Tube Current (mA)	Field Size
		inches × inches

Scattering Phantom Description:

Radiation Detection meter used: Mfg: _____ s/n: _____ Cal. Date: _____

	Exposure Time (s)	Measured Dose (µR)	Energy Correction Factor	Dose per Exposure (µR)	Exposures per week	Dose per week @ 1 meter (µR)
1						
2						
3						
4						

	Distance to most exposed person (meters)	Weekly dose to most exposed person (µR)	Weeks per year of exposure	Annual Dose to most exposed person (mR)
1				
2				
3				
4				

Leakage Measurements (required initially, when x-ray tube is replaced, or when repairs involve the protective housing)

☐ See report dated _____ for last leakage measurement

1 meter from tube housing,; collimators shut and output port blocked with ≥⅛ inch lead; maximum kVp and mA.

Location	High Voltage (kVp)	Tube Current (mA)	Exposure Time (s)	Measured Dose (µR)	Dose Rate (mR/h)

Audit

		Yes	No	n/a
1	Dose to operator less than 500 mrem per year.	☐	☐	☐
2	Doses to members of public do not exceed 100 mrem/year	☐	☐	☐
3	A clearly legible and visible label bearing the statement: "Caution: X-Rays Produced When Energized" is permanently affixed or inscribed at the controls	☐	☐	☐
4	Manufacturer's operating manual(s) and instructions are available.	☐	☐	☐
5	Individual operating the unit has received radiation safety training	☐	☐	☐
6	Lead apron or portable lead shield available	☐	☐	☐
7	Personal radiation monitoring devices worn	☐	☐	☐
8	Object being imaged and image receptor (e.g., film cassette) are NOT held during exposure	☐	☐	☐
9	Tube housing and collimator are NOT held during exposure	☐	☐	☐
10	Leakage radiation is less than 100 mR/hour	☐	☐	☐
11	Technique factors (kVp, mA, exposure time) are displayed	☐	☐	☐
12	Deadman switch	☐	☐	☐
13	Exposure switch in protected area or allows operator to stand 2 meters away	☐	☐	☐
14	Visual indication when X-rays are being produced.	☐	☐	☐
15	An audible signal indicates that the exposure has terminated	☐	☐	☐
16	Means to collimate the useful beam provided	☐	☐	☐
17	Light field or other means provided to define the x-ray field	☐	☐	☐
Comments:				

Audit performed by: _____

Reviewed by: _____

Jon M. Chase, M.S.
Radiation Safety Officer

Radiation Physics and Safety Division

Laboratory Audit Results

Name of Authorized User:_____ Authorization #: _____

Laboratory Rooms Inspected:_____

The following information is the result of an audit of your laboratory area(s) that was conducted by the Radiation Safety Office on _____.

All items are scored on a pass/fail basis. Any item marked fail **must** be responded to within 30 days from the date of this report. Each failed item will require a plan of action and immediate implementation. We will return at a later date to review the implementation of your corrective action.

At the end of this report you will find recommendations that we feel will enhance your overall program.

I. Signage (R/A Materials Signs)	Pass	Fail	N/A
Doors	☐	☐	☐
Hoods	☐	☐	☐
Refrigerators/Freezers/Cabinets	☐	☐	☐
Disposal sink(s)	☐	☐	☐
Equipment	☐	☐	☐
Comments:			

II. Postings	Pass	Fail	N/A
Current PA State posting (dated 8/2008)	☐	☐	☐
Drain disposal sink limits	☐	☐	☐
Drain disposal sink disposal chart	☐	☐	☐
General Laboratory Radiation Safety Instructions and Emergency Instructions	☐	☐	☐
Comments:			

III. Records	Pass	Fail	N/A
Authorization Document	☐	☐	☐
Radiation Safety Manual	☐	☐	☐
Receipt of shipment records	☐	☐	☐
Disposition of Material Records	☐	☐	☐
Quarterly Inventory	☐	☐	☐
Wipe Test Records*	☐	☐	☐
A. Number of points wiped sufficient	☐	☐	☐
B. Performed after every experiment or once a month, whichever is more frequent	☐	☐	☐
C. Results expressed in dpm/100 cm^2	☐	☐	☐
D. Action level of 1000 dpm/100 cm^2 listed on survey form	☐	☐	☐
E. Evidence of contamination/clean-up	☐	☐	☐
Comments:			

IV. Radiation Detection Equipment	Pass	Fail	N/A
Detection equipment available: Mfg ____Ludlum _ Model # __3____ S/N 222398_ Detector type: 44-7___ Mfg ____Ludlum _ Model # __3____ S/N 222443_ Detector type: 44-9___			
Meter has check source	☐	☐	☐
Meter operates properly (battery check satisfactory, detects radiation)	☐	☐	☐
Meter calibrated within past year or labeled "For detection only"	☐	☐	☐
Meter adequate to measure radioactive materials in use (e.g., LSC for ^{3}H, GM for other beta emitters, LEG scintillation probe for ^{125}I)	☐	☐	☐
Comments:			

V. Laboratory Security	Pass	Fail	N/A
Labs locked when unattended	☐	☐	☐
Refrigerators and walk-in freezers in corridors secured	☐	☐	☐
Comments:			

VI. Personnel Training	Pass	Fail	N/A
Personnel attended the Radiation Safety Short Course or have previous training and experience	☐	☐	☐
Personnel appear knowledgeable of radiation safety requirements at time of inspection	☐	☐	☐
Personnel received instructions/orientation from principal investigator prior to RAM work	☐	☐	☐
Comments:			

VII. Waste Disposal	Pass	Fail	N/A
Appropriate waste containers with CRAM labeling and inventory of contents	☐	☐	☐
Disposal records maintained	☐	☐	☐
Segregation of wastes by half-life and waste stream (e.g., LSC vials separate from dry waste)	☐	☐	☐
Decay in storage waste transferred to RPSD	☐	☐	☐
Release of materials to unrestricted areas	☐	☐	☐
Comments:			

VIII. Work Area	Pass	Fail	N/A
Area free of unnecessary clutter	☐	☐	☐
Radioactive use areas clearly delineated	☐	☐	☐
Absorbent paper/drip trays in use	☐	☐	☐
Shielding available	☐	☐	☐
Comments:			

IX. Work Procedures	Pass	Fail	N/A
No eating, drinking, smoking, application of cosmetics observed and no evidence of same	☐	☐	☐
Lab coats/gloves and other appropriate personal protective equipment worn	☐	☐	☐
Film/TLD badges worn and stored properly	☐	☐	☐
Shielding in use	☐	☐	☐
Comments:			

Recommendations:

Your response **must** be submitted within 30 days of receipt to the Radiation Safety Office.

Audit performed by: _____
Radiation Safety Technician

Reviewed by: _____
Jon M. Chase, M.S.
Radiation Safety Officer

Section IV. Appendix

IV. a. Isotope Fact Sheets

FACT SHEETS

Index

Isotope Data

H-3 (Tritium)
C-14
Na-22
P-32
P-33
S-35
Ca-45
Cr-51
Ni-63
Rb-86
Tc-99m
I-125

Hydrogen

H-3 (tritium)

Atomic Number: 1

Half Life: 12.280 Years

Decay Table (elapsed time = years + months; read fraction remaining. E.g., 83.6% remains after 3 years & 2 months)

Years \ Months	0	1	2	3	4	5	6	7	8	9	10	11
0	1.0000	0.9953	0.9906	0.9860	0.9814	0.9768	0.9722	0.9676	0.9631	0.9585	0.9541	0.9496
1	0.9451	0.9407	0.9363	0.9319	0.9275	0.9231	0.9188	0.9145	0.9102	0.9059	0.9017	0.8975
2	0.8932	0.8891	0.8849	0.8807	0.8766	0.8725	0.8684	0.8643	0.8603	0.8562	0.8522	0.8482
3	0.8442	0.8403	0.8363	0.8324	0.8285	0.8246	0.8207	0.8169	0.8130	0.8092	0.8054	0.8017
4	0.7979	0.7941	0.7904	0.7867	0.7830	0.7793	0.7757	0.7720	0.7684	0.7648	0.7612	0.7577
5	0.7541	0.7506	0.7470	0.7435	0.7400	0.7366	0.7331	0.7297	0.7263	0.7228	0.7195	0.7161
6	0.7127	0.7094	0.7060	0.7027	0.6994	0.6962	0.6929	0.6896	0.6864	0.6832	0.6800	0.6768
7	0.6736	0.6704	0.6673	0.6642	0.6610	0.6579	0.6549	0.6518	0.6487	0.6457	0.6427	0.6396
8	0.6366	0.6336	0.6307	0.6277	0.6248	0.6218	0.6189	0.6160	0.6131	0.6102	0.6074	0.6045
9	0.6017	0.5989	0.5961	0.5933	0.5905	0.5877	0.5849	0.5822	0.5795	0.5768	0.5740	0.5714
10	0.5687	0.5660	0.5633	0.5607	0.5581	0.5555	0.5528	0.5503	0.5477	0.5451	0.5425	0.5400
11	0.5375	0.5349	0.5324	0.5299	0.5274	0.5250	0.5225	0.5201	0.5176	0.5152	0.5128	0.5104
12	0.5080	0.5056	0.5032	0.5008	0.4985	0.4962	0.4938	0.4915	0.4892	0.4869	0.4846	0.4824

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.0186	0.005685	1.000

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 80,000 μCi

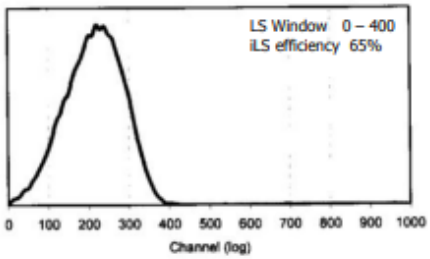
Inhalation: 80,000 μCi

Skin Dose: 0 $\frac{\text{rad}}{\text{hr}}$ per μCi on 1 cm^2 of skin

Maximum Range of Beta in Air: 4.7 mm (0.19 in.)

Shielding: No shielding required.

Detection: Liquid scintillation counting



GM efficiency (4π at 1 cm) End window: 0.0%. Pancake: 0.0%.

Special Considerations:

- The low energy beta makes tritium less hazardous than many isotopes, but also makes it harder to detect.
- Many tritium compounds readily penetrate gloves and skin. Handle these compounds remotely, wear two pairs of gloves and change the outer layer at least every 20 minutes.

Carbon **C-14** Atomic Number: 6

Half Life: 5,730 Years

Decay Table (elapsed time = years in row + years in column; read fraction remaining. E.g., 99.6% remains after 36 years)

Years \ Year	0	1	2	3	4	5	6	7	8	9
0	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9999	0.9999	0.9999	0.9999
10	0.9988	0.9988	0.9988	0.9988	0.9988	0.9987	0.9987	0.9987	0.9987	0.9987
20	0.9976	0.9976	0.9976	0.9976	0.9975	0.9975	0.9975	0.9975	0.9975	0.9975
30	0.9964	0.9964	0.9964	0.9963	0.9963	0.9963	0.9963	0.9963	0.9963	0.9963
40	0.9952	0.9952	0.9952	0.9951	0.9951	0.9951	0.9951	0.9951	0.9951	0.9951
50	0.9940	0.9940	0.9939	0.9939	0.9939	0.9939	0.9939	0.9939	0.9939	0.9939

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.15648	0.04947	1.000

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 2,000 μCi

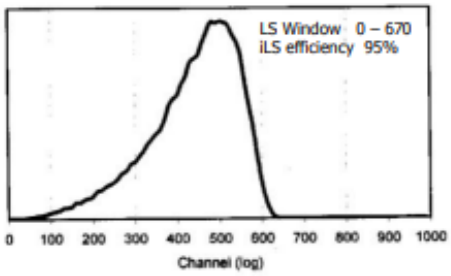
Inhalation: 2,000 μCi

Skin Dose: 1.2 $\frac{rad}{hr}$ per μCi on 1 cm^2 of skin

Maximum Range of Beta in Air: 22 cm (8.6 in.)

Shielding: No shielding required.

Detection: Liquid scintillation counting.



GM efficiency (4π at 1 cm) End window: ~2%. Pancake: ~4%.
(Note: covering of probe with plastic wrap or paraffin renders it ineffective.)

Special Precautions:

- Some ^{14}C-labeled compounds may penetrate gloves and skin. For these compounds, wear two pairs of gloves and change the outer layer frequently.
- Halogenated acids labeled with ^{14}C can be incorporated in the skin and deliver local doses in the order of 10-100 rad per μCi deposited.

Sodium **Na-22** **Atomic Number: 11**

Half Life: 2.602 Years

Decay Table (elapsed time = years + months; read fraction remaining. E.g., 43% remains after 3 years & 2 months)

Years \ Months	0	1	2	3	4	5	6	7	8	9	10	11
0	1.0000	0.9780	0.9566	0.9356	0.9150	0.8949	0.8753	0.8561	0.8373	0.8189	0.8009	0.7833
1	0.7661	0.7493	0.7329	0.7168	0.7010	0.6857	0.6706	0.6559	0.6415	0.6274	0.6136	0.6001
2	0.5870	0.5741	0.5615	0.5492	0.5371	0.5253	0.5138	0.5025	0.4915	0.4807	0.4701	0.4598
3	0.4497	0.4398	0.4302	0.4207	0.4115	0.4025	0.3936	0.3850	0.3765	0.3683	0.3602	0.3523
4	0.3445	0.3370	0.3296	0.3223	0.3153	0.3083	0.3016	0.2949	0.2885	0.2821	0.2759	0.2699
5	0.2640	0.2582	0.2525	0.2470	0.2415	0.2362	0.2310	0.2260	0.2210	0.2162	0.2114	0.2068
6	0.2022	0.1978	0.1934	0.1892	0.1850	0.1810	0.1770	0.1731	0.1693	0.1656	0.1620	0.1584
7	0.1549	0.1515	0.1482	0.1450	0.1418	0.1387	0.1356	0.1326	0.1297	0.1269	0.1241	0.1214
8	0.1187	0.1161	0.1135	0.1111	0.1086	0.1062	0.1039	0.1016	0.0994	0.0972	0.0951	0.0930
9	0.0909	0.0889	0.0870	0.0851	0.0832	0.0814	0.0796	0.0779	0.0761	0.0745	0.0728	0.0712

Positron Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.54552	0.21554	0.8984
2.8421	0.83480	0.0006

Conversion and Auger Electron Emission

Energy (MeV)	emission per disintegration
0.00820	0.092

Photon Emission

Energy (MeV)	emission per disintegration
0.00849	0.00125
0.511	1.798
1.2745	0.9994

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 400 μCi

Inhalation: 600 μCi

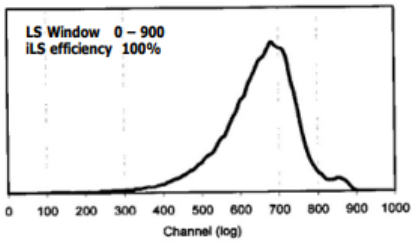
Skin Dose: 6.3 $\frac{\text{rad}}{\text{hr}}$ per μCi on 1 cm^2 of skin

Maximum range of positron in air: 140 cm (56 in.)

Unshielded exposure rate at 1 cm from a 1 mCi point source: 11.8 R/h

Half-Value layer for Lead Shielding: 6.5 mm (0.26 in.)

Detection: Liquid scintillation counting



Crystal scintillation well counting. Thick (1″ x 1″) crystal scintillation detector.
GM efficiency (4π at 1 cm) End window: 0.0%. **Pancake**: ~4%.

Special Precautions:

- Store ^{22}Na behind thick lead shields.
- Dose rates due to positron radiation can be much higher than dose rates due to x and gamma radiation near an unshielded source. Use acrylic shielding to avoid eye exposure.
- Avoid skin exposure by indirect handling and prompt removal of contamination or contaminated clothing.

Phosphorus **P-32** Atomic Number: 15

Half Life: 14.290 Days

Decay Table (elapsed time = days in columns + days in rows; read fraction remaining. E.g., 20% remains after 33 days)

Days	0	1	2	3	4	5	6	7	8	9
0	1.0000	0.9527	0.9075	0.8646	0.8236	0.7846	0.7475	0.7121	0.6784	0.6463
10	0.6157	0.5865	0.5587	0.5323	0.5071	0.4831	0.4602	0.4384	0.4177	0.3979
20	0.3790	0.3611	0.3440	0.3277	0.3122	0.2974	0.2833	0.2699	0.2571	0.2450
30	0.2334	0.2223	0.2118	0.2018	0.1922	0.1831	0.1744	0.1662	0.1583	0.1508
40	0.1437	0.1369	0.1304	0.1242	0.1183	0.1127	0.1074	0.1023	0.0975	0.0928
50	0.0885	0.0843	0.0803	0.0765	0.0729	0.0694	0.0661	0.0630	0.0600	0.0572
60	0.0545	0.0519	0.0494	0.0471	0.0449	0.0427	0.0407	0.0388	0.0369	0.0352
70	0.0335	0.0319	0.0304	0.0290	0.0276	0.0263	0.0251	0.0239	0.0227	0.0217
80	0.0206	0.0197	0.0187	0.0178	0.0170	0.0162	0.0154	0.0147	0.0140	0.0133
90	0.0127	0.0121	0.0115	0.0110	0.0105	0.0100	0.0095	0.0090	0.0086	0.0082

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
1.7104	0.6949	1.000

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 600 μCi
Inhalation: 400 μCi

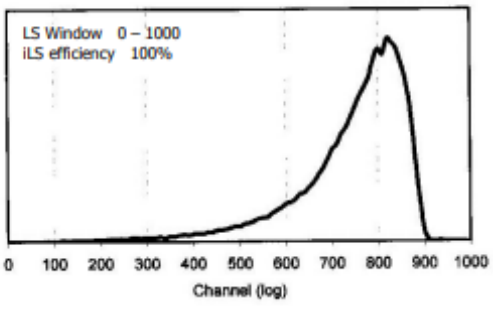
Skin Dose: 7.0 $\frac{rad}{hr}$ per μCi on 1 cm^2 of skin

The high energy beta from ^{32}P can deliver a high radiation dose to local areas of the skin in a short period of time if contamination of the skin or gloves is allowed to remain.

Maximum Range of Beta: in Air: 6 m (20 ft) in water: 8 mm (0.3 in)

Shielding: Acrylic (e.g., Lucite, Plexiglas) ⅜-inch thick, or other plastic that will absorb the beta particles while generating little secondary radiation.. Do not use lead foil alone. For millicurie quantities of ^{32}P, add ⅛-inch - ¼-inch thick lead to the exterior of the acrylic shield to absorb the more penetrating secondary radiation.

Detection: Liquid scintillation counting.



GM efficiency (4π at 1 cm) End window: ~10%. Pancake: 30%.

Special Considerations:

- Do not work over open containers. The dose rate at the mouth of an open combi-vial containing 1 mCi of ^{32}P in 1 ml of liquid is roughly 26 rem/hour. Both the hands and face can receive a considerable dose near an open container of ^{32}P.
- Avoid skin exposure by using tools to indirectly handle unshielded sources and potentially contaminated vessels.

Phosphorus **P-33** Atomic Number: 15

Half Life: 25.400 Days

Decay Table (elapsed time = days in columns + days in rows; read fraction remaining. E.g., 30% remains after 44 days)

Days	0	1	2	3	4	5	6	7	8	9
0	1.0000	0.9731	0.9469	0.9214	0.8966	0.8725	0.8490	0.8261	0.8039	0.7822
10	0.7612	0.7407	0.7207	0.7013	0.6825	0.6641	0.6462	0.6288	0.6119	0.5954
20	0.5794	0.5638	0.5486	0.5338	0.5195	0.5055	0.4919	0.4786	0.4658	0.4532
30	0.4410	0.4291	0.4176	0.4063	0.3954	0.3848	0.3744	0.3643	0.3545	0.3450
40	0.3357	0.3267	0.3179	0.3093	0.3010	0.2929	0.2850	0.2773	0.2699	0.2626
50	0.2555	0.2486	0.2419	0.2354	0.2291	0.2229	0.2169	0.2111	0.2054	0.1999
60	0.1945	0.1893	0.1842	0.1792	0.1744	0.1697	0.1651	0.1607	0.1563	0.1521
70	0.1480	0.1441	0.1402	0.1364	0.1327	0.1292	0.1257	0.1223	0.1190	0.1158
80	0.1127	0.1097	0.1067	0.1038	0.1010	0.0983	0.0957	0.0931	0.0906	0.0881
90	0.0858	0.0835	0.0812	0.0790	0.0769	0.0748	0.0728	0.0709	0.0690	0.0671
100	0.0653	0.0635	0.0618	0.0602	0.0585	0.0570	0.0554	0.0539	0.0525	0.0511
110	0.0497	0.0484	0.0471	0.0458	0.0446	0.0434	0.0422	0.0411	0.0399	0.0389
120	0.0378	0.0368	0.0358	0.0349	0.0339	0.0330	0.0321	0.0313	0.0304	0.0296

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.249	0.0766	1.000

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 6,000 μCi

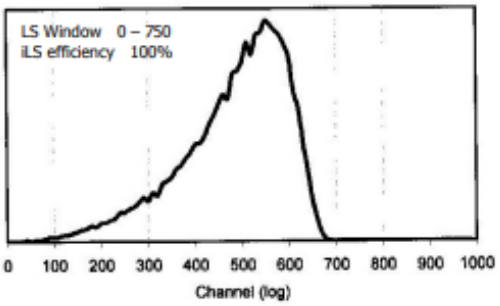
Inhalation: 3,000 μCi

Skin Dose: 3.2 $\frac{\text{rad}}{\text{hr}}$ per μCi on 1 cm^2 of skin

Maximum Range of Beta in Air: 46 cm (18 in.)

Shielding: None for <1 mCi; ⅛ inch thick acrylic (Lucite, Plexiglas) for>1 mCi.

Detection: Liquid scintillation counting



GM efficiency (4π at 1 cm) End window: ~4%. Pancake: ~8%.
(Note: covering of probe with plastic wrap or paraffin renders it ineffective.)

Sulfur **S-35** Atomic Number: 16

Half Life: 87.440 Days

Decay Table

Weeks	0	1	2	3	4
0	1.0000	0.9460	0.8949	0.8466	0.8009
5	0.7576	0.7167	0.6780	0.6414	0.6068
10	0.5740	0.5430	0.5137	0.4859	0.4597
15	0.4349	0.4114	0.3892	0.3681	0.3483
20	0.3295	0.3117	0.2948	0.2789	0.2639
25	0.2496	0.2361	0.2234	0.2113	0.1999
30	0.1891	0.1789	0.1692	0.1601	0.1514
35	0.1433	0.1355	0.1282	0.1213	0.1147
40	0.1085	0.1027	0.0971	0.0919	0.0869
45	0.0822	0.0778	0.0736	0.0696	0.0659
50	0.0623	0.0589	0.0558	0.0527	0.0499

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.16747	0.04883	1.000

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 6,000 μCi

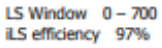
Inhalation: 2,000 μCi

Skin Dose: 1.3 $\frac{rad}{hr}$ per μCi on 1 cm^2 of skin

Maximum Range of Beta in Air: 24 cm (9.6 in.)

Shielding: No shielding required.

Detection: Liquid scintillation counting.



GM efficiency (4π at 1 cm) End window: ~2%. Pancake: ~5%.
(Note: covering of probe with plastic wrap or paraffin renders it ineffective.)

Special Considerations:

- Methionine, cysteine and Translabel® may be volatile and should be used in a fume hood.
- Activated charcoal and copper turnings are effective in reducing airborne contamination.
- Tools and equipment, such as incubators, should be checked for contamination after using ^{35}S-methionine or other volatile compounds. Contamination may be found on the inside surfaces and in water reservoirs of incubators used for ^{35}S work, particularly rubber seals.
- ^{35}S may be difficult to distinguish from ^{14}C because the beta emissions are of similar energy.

Calcium **Ca-45** Atomic Number: 20

Half Life: 162.700 Days

Decay Table

Days	0	7	14	21	28
0	1.0000	0.9706	0.9421	0.9144	0.8876
35	0.8615	0.8362	0.8116	0.7877	0.7646
70	0.7421	0.7203	0.6992	0.6786	0.6587
105	0.6393	0.6205	0.6023	0.5846	0.5674
140	0.5508	0.5346	0.5189	0.5036	0.4888
175	0.4745	0.4605	0.4470	0.4339	0.4211
210	0.4087	0.3967	0.3851	0.3738	0.3628
245	0.3521	0.3418	0.3317	0.3220	0.3125
280	0.3033	0.2944	0.2858	0.2774	0.2692
315	0.2613	0.2536	0.2462	0.2390	0.2319
350	0.2251	0.2185	0.2121	0.2059	0.1998
385	0.1939	0.1882	0.1827	0.1773	0.1721
420	0.1671	0.1622	0.1574	0.1528	0.1483

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.2455	0.092	0.000017
0.256900	0.0772	0.99998

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

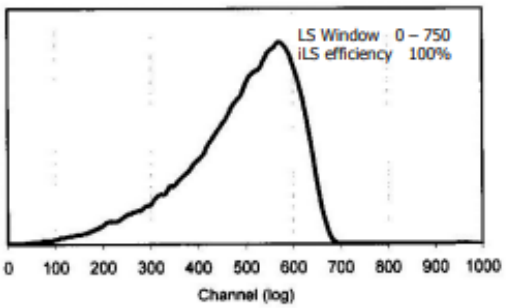
Ingestion: 2,000 μCi

Inhalation: 800 μCi

Skin Dose: 3.1 $\frac{\text{rad}}{\text{hr}}$ per μCi on 1 cm^2 of skin

Maximum Range of Beta in Air: 48 cm (19 in.)

Detection: Liquid scintillation counting.



GM efficiency (4π at 1 cm) End window: ~4%. Pancake: ~8%.

(Note: covering of probe with plastic wrap or paraffin significantly reduced efficiency.)

Chromium **Cr-51** Atomic Number: 24

Half Life: 27.704 Days

Decay Table

Days	0	1	2	3	4	5	6	7	8	9
0	1.0000	0.9753	0.9512	0.9277	0.9048	0.8824	0.8606	0.8393	0.8186	0.7983
10	0.7786	0.7594	0.7406	0.7223	0.7045	0.6870	0.6701	0.6535	0.6374	0.6216
20	0.6062	0.5913	0.5767	0.5624	0.5485	0.5349	0.5217	0.5088	0.4963	0.4840
30	0.4720	0.4604	0.4490	0.4379	0.4271	0.4165	0.4062	0.3962	0.3864	0.3768
40	0.3675	0.3585	0.3496	0.3410	0.3325	0.3243	0.3163	0.3085	0.3009	0.2934
50	0.2862	0.2791	0.2722	0.2655	0.2589	0.2525	0.2463	0.2402	0.2343	0.2285
60	0.2228	0.2173	0.2119	0.2067	0.2016	0.1966	0.1918	0.1870	0.1824	0.1779
70	0.1735	0.1692	0.1650	0.1609	0.1570	0.1531	0.1493	0.1456	0.1420	0.1385
80	0.1351	0.1317	0.1285	0.1253	0.1222	0.1192	0.1163	0.1134	0.1106	0.1078
90	0.1052	0.1026	0.1000	0.0976	0.0952	0.0928	0.0905	0.0883	0.0861	0.0840

Conversion and Auger Electron Emission

Energy (MeV)	emission per disintegration
0.00047	1.4468
0.00438	0.66886

Photon Emission

Energy (MeV)	emission per disintegration
0.004945	0.06594
0.00495	0.13084
0.00543	0.02617
0.32008	0.09830

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 40,000 μCi

Inhalation: 20,000 μCi

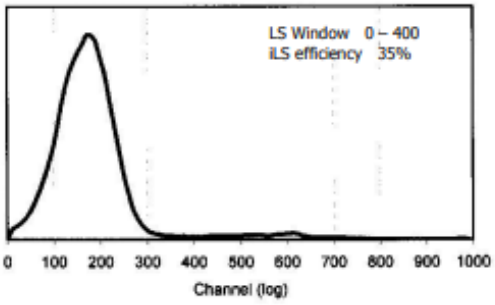
Skin Dose: 0.056 $\frac{\text{rad}}{\text{hr}}$ per μCi on 1 cm^2 of skin

Unshielded exposure rate at 1 cm from a 1 mCi point source: 0.18 R/h

Half-value layer for lead shielding: 1.7 mm (0.067 in)

Detection: Crystal scintillation detector

Liquid scintillation detector



Special Considerations:

- Store ^{51}Cr behind lead shielding.

Nickel **Ni-63** Atomic Number: 28

Half Life: 100.100 Years

Decay Table

Years \ Year	0	1	2	3	4	5	6	7	8	9
0	1.0000	0.9994	0.9988	0.9983	0.9977	0.9971	0.9965	0.9960	0.9954	0.9948
10	0.9331	0.9326	0.9320	0.9315	0.9309	0.9304	0.9299	0.9293	0.9288	0.9283
20	0.8707	0.8702	0.8697	0.8692	0.8687	0.8682	0.8677	0.8672	0.8667	0.8662
30	0.8124	0.8120	0.8115	0.8110	0.8105	0.8101	0.8096	0.8091	0.8087	0.8082
40	0.7581	0.7576	0.7572	0.7568	0.7563	0.7559	0.7554	0.7550	0.7546	0.7541
50	0.7074	0.7069	0.7065	0.7061	0.7057	0.7053	0.7049	0.7045	0.7041	0.7037

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.065870	0.017130	1.000

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

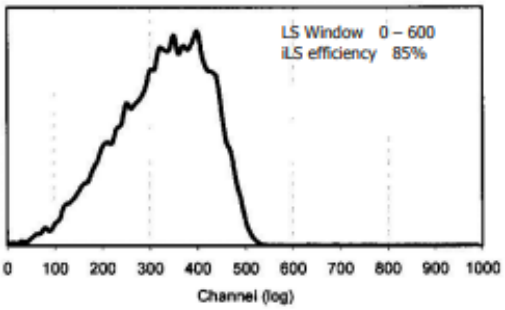
Ingestion: 9,000 μCi

Inhalation: 800 μCi

Skin Dose: 0 $\frac{rad}{hr}$ per μCi on 1 cm^2 of skin

Maximum Range of Beta in Air: 5 cm (2 in.)

Detection: Liquid Scintillation Counting



GM efficiency (4π at 1 cm) End window: 0.0%. Pancake: 0.0%.

Special Considerations:

- The low energy beta makes nickel-63 less hazardous than many isotopes, but also make it harder to detect.

Rubidium **Rb-86** Atomic Number: 37

Half Life: 18.660 Days

Decay Table

Days	0	1	2	3	4	5	6	7	8	9
0	1.0000	0.9635	0.9284	0.8945	0.8619	0.8305	0.8002	0.7710	0.7429	0.7158
10	0.6897	0.6646	0.6403	0.6170	0.5945	0.5728	0.5519	0.5318	0.5124	0.4937
20	0.4757	0.4584	0.4417	0.4256	0.4100	0.3951	0.3807	0.3668	0.3534	0.3405
30	0.3281	0.3162	0.3046	0.2935	0.2828	0.2725	0.2626	0.2530	0.2438	0.2349
40	0.2263	0.2181	0.2101	0.2024	0.1951	0.1880	0.1811	0.1745	0.1681	0.1620
50	0.1561	0.1504	0.1449	0.1396	0.1345	0.1296	0.1249	0.1204	0.1160	0.1117
60	0.1077	0.1037	0.1000	0.0963	0.0928	0.0894	0.0862	0.0830	0.0800	0.0771
70	0.0743	0.0715	0.0689	0.0664	0.0640	0.0617	0.0594	0.0573	0.0552	0.0532

Beta Emission

Maximum Energy (MeV)	Average Energy (MeV)	emission per disintegration
0.69764	0.2325	0.0878
1.7744	0.7093	0.9122

Photon Emission

Energy (MeV)	emission per disintegration
1.0766	0.087795

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 500 μCi Inhalation: 800 μCi

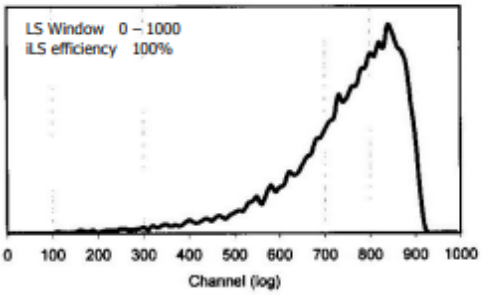
Skin Dose: 0 $\frac{rad}{hr}$ per μCi on 1 cm^2 of skin

Maximum range of beta: in air: 6.4 m (21 ft) in water: 8 mm (0.3 in)

Unshielded exposure rate at 1 cm from a 1 mCi point source: 0.5 R/h

Half-value layer for lead shielding: 9.0 mm (0.3 in)

Detection: Liquid scintillation counting



Crystal scintillation well counting;
Thin window GM (primarily detects beta particles) with efficiencies similar to ^{32}P.

Special Considerations:

- The high energy beta emissions from ^{86}Rb can present a substantial skin and eye exposure hazard.
- The high energy gamma emissions and secondary radiation presents a penetrating external hazard.
- Store ^{86}Rb behind thick lead shields.
- Dose rates due to beta radiation can be much higher than dose rates due to x and gamma radiation near an unshielded source. Use acrylic shielding to avoid eye exposure.
- Avoid skin exposure by indirect handling and prompt removal of contamination or contaminated clothing.

Technetium **Tc-99m** Atomic Number: 43

Half Life: 6.020 Hours

Decay Table

Hours	0	1	2	3	4	5
0	1.0000	0.8912	0.7943	0.7079	0.6309	0.5623
6	0.5012	0.4466	0.3981	0.3548	0.3162	0.2818
12	0.2512	0.2238	0.1995	0.1778	0.1585	0.1412
18	0.1259	0.1122	0.1000	0.0891	0.0794	0.0708
24	0.0631	0.0562	0.0501	0.0447	0.0398	0.0355
30	0.0316	0.0282	0.0251	0.0224	0.0199	0.0178
36	0.0158	0.0141	0.0126	0.0112	0.0100	0.0089
42	0.0079	0.0071	0.0063	0.0056	0.0050	0.0045
48	0.0040	0.0035	0.0032	0.0028	0.0025	0.0022

Conversion and Auger Electron Emission

Energy (MeV)	emission per disintegration
0.001626	0.745460
0.002102	0.24584
0.002170	0.10268
0.01550	0.020788
0.11946	0.087928
0.13747	0.010607
0.13996	0.0023

Photon Emission

Energy (MeV)	emission per disintegration
0.018251	0.021021
0.018367	0.040194
0.0206	0.012059
0.14051	0.8907

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingeston: 80,000 μCi

Inhalation: 200,000 μCi

Skin Dose: 0.9 $\frac{\text{rad}}{\text{hr}}$ per μCi on 1 cm^2 of skin

Maximum range of beta in air: 63 cm (25 in)

Unshielded exposure rate 1 cm from a 1 mCi point source: 0.77 R/hr

Half-value layer for lead shielding: 0.27 mm (0.01 in)

Detection: Crystal Scintillation Detector, Thin window GM (Pancake GM efficiency ~1%)

Special Considerations:

- The short half-life can be used to ones advantage to reduce dose.

Iodine **I-125** Atomic Number: 53

Half Life: 60.140 Days

Decay Table

Days	0	5	10	15	20	25	30	35	40	45
0	1.0000	0.9440	0.8911	0.8412	0.7941	0.7497	0.7077	0.6680	0.6306	0.5953
50	0.5620	0.5305	0.5008	0.4728	0.4463	0.4213	0.3977	0.3754	0.3544	0.3346
100	0.3158	0.2981	0.2814	0.2657	0.2508	0.2368	0.2235	0.2110	0.1992	0.1880
150	0.1775	0.1676	0.1582	0.1493	0.1410	0.1331	0.1256	0.1186	0.1119	0.1057
200	0.0997	0.0942	0.0889	0.0839	0.0792	0.0748	0.0706	0.0666	0.0629	0.0594
250	0.0561	0.0529	0.0500	0.0472	0.0445	0.0420	0.0397	0.0374	0.0354	0.0334
300	0.0315	0.0297	0.0281	0.0265	0.0250	0.0236	0.0223	0.0210	0.0199	0.0188
350	0.0177	0.0167	0.0158	0.0149	0.0141	0.0133	0.0125	0.0118	0.0112	0.0105

Conversion and Auger Electron Emission

Energy (MeV)	emission per disintegration
0.003190	1.561
0.003678	0.7788
0.022700	0.19691
0.030553	0.12266
0.034486	0.024662
0.035324	0.008112

Photon Emission

Energy (MeV)	emission per disintegration
0.003770	0.154380
0.027202	0.392330
0.027472	0.731960
0.031000	0.254090
0.035492	0.064900

Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

Ingestion: 40μCi

Inhalation: 60 μCi

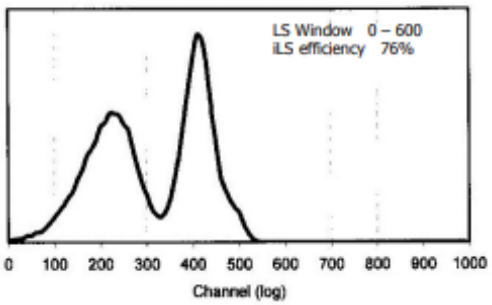
Skin Dose: 0.07 $\frac{\text{rad}}{\text{hr}}$ per μCi on 1 cm^2 of skin

Unshielded Exposure Rate for 1 mCi Point Source at 1 cm: 1.4 R/h

Half-Value Layer for Lead Shielding: 0.02 mm (0.001 in.)

Detection: Crystal Scintillation Detector

Liquid Scintillation Detector



GM efficiency (4π at 1 cm) Pancake: ~0.1%.

Special Considerations:

- Store $Na^{125}I$ solutions at room temperature because freezing results in subsequent volatilization of radioiodine.
- Avoid acidic solutions to minimize volatilization.
- Some radioiodine compounds may penetrate gloves and skin. Therefore, these compounds should be handled indirectly by using tools and wearing two pairs of gloves. The outer layer of gloves should be changed frequently and whenever they are suspected to be contaminated.