University Radiation Safety Manual

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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, and 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 procedures take precedent (i.e., specific policies and procedures supersede 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.

Summary

The possession and use of radioactive materials and radiation producing machines are controlled by the state or federal government through licenses and registrations issued through regulatory agencies and through published regulations.
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 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.

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 Safety and Health). The Radiation Safety Officer is a permanent member of the Committee and the Vice Provost for Regulatory Research Compliance is an *ex officio* member 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:

- 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

<table>
<thead>
<tr>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Radiation Safety Committee is a peer review committee responsible for establishing radiation safety policies and procedures, approving users and uses of sources of radiation, and overseeing the radiation safety program.</td>
</tr>
</tbody>
</table>
radiation safety program administrative structure

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.

- 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.

Summary

The Radiation Safety Officer (RSO) implements the radiation safety program established by the Radiation Safety Committee and assists the Committee discharge its duties. The RSO is the primary resource for all activities related to the use of sources of radiation. Always feel free to contact the RSO for any radiation safety related issues.
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I. E. 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 to the Radiation Safety Committee to conduct their activities as authorized by the Committee and in accordance with the policies and procedures established by the Committee.

Summary

Authorized users are responsible to the Radiation Safety Committee for compliance with the University’s radiation safety policies and procedures. This includes conducting surveys, training personnel, accounting for radioactive material, maintaining required documentation, and conducting activities as authorized by the Radiation Safety 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. The term “under the supervision” does not imply that the authorized user must be physically present. Supervised users may include research assistants, laboratory technicians, graduate students, etc.
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.

Summary

To become an authorized user:

- Become familiar with applicable requirements in this manual.
- Complete the application form and submit it to the Radiation Safety Officer. The RSO will contact you to schedule an interview.
- Upon approval from the Radiation Safety Committee and before receiving a source of radiation, contact the Radiation Safety Office to set-up your facility (e.g., posting and labeling).
Section II
General Radiation Safety Policies and Procedures

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.

Applying for Authorized Uses

Applications for proposed uses of radioactive material must 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 handling 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.

Summary

The application for authorized uses is integral with the initial application to become an authorized user. Additional proposed uses require an amendment to your existing authorization. To add a new use complete the amendment form. Amendments to your authorization are also required to:

- Increase the amount of radioactive material allowed on hand.
- Increase the amount of radioactive material disposed into sinks.
- Add or change the chemical form (e.g., from $^{32}$P dATP to $^{32}$P orthophosphate)
- Add or change physical form (e.g., from a solution to a powder)
- Move to a new facility.
Section II
General Radiation Safety Policies and Procedures

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 a possession limit.

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

Each new supervised user is to receive an orientation on radiation safety practices before commencing work with sources of radiation. The Radiation Safety Office 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 group or 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 material 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.
- Worker's 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
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- Radiation protection
- Radiation detection
- Personnel monitoring
- Federal regulations
- Institutional controls
- General laboratory radiation safety procedures
- Posting and labeling
- Radiological contamination
- 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 on occasion 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 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 successfulness 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 exposures 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 likely to receive an external radiation dose in excess of 10 percent of the annual dose limit (whole body doses in excess of 500 millirem in a year).
- Minors who are likely to receive an external dose in excess of 100 millirem in a year.
- Declared pregnant women who are likely to receive an external dose of 100 millirem during gestation.
- Individual 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 judgment 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.
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External dosimeters will be provided to individuals who require monitoring and will be exchanged on a monthly basis. 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 Radiation Safety Office reserves the right to recoup the replacement costs of lost or damaged monitoring devices from the monitored individual’s department should these become excessive (e.g., >5%).

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 the prior exposure history from prior employers for each individual 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 sources of radiation.
- A temporary monitor may be issued until the beginning of the next exchange period.
- 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 the 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 at the University.
- Individuals must never purposely expose their dosimeter to radiation for any reason. If it is desired to run a test on a dosimeter, the Radiation Safety Office 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 dosimeter only when working at the University.
  - Do not wear dosimeter while being exposed to radiation for personal medical reasons. (e.g., chest film, dental x-rays, and nuclear medicine scans)
  - Do not take dosimeter home; leave it 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 dosimeter until the beginning of the next exchange period.
  - Return old dosimeter immediately to the collection point in your department.
  - If there is not a new dosimeter at the collection point, contact Radiation Safety immediately and continue to wear the old badge.
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- 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 dosimeter immediately to the Radiation Safety Officer for replacement. Temporary dosimeters will be issued in the case of loss or damage.
- Wear 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 (ones’ 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 an 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 Radiation Safety Office 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 he/she conducts certain types of experiments or procedures with volatile radionuclides. Radiation workers are required to participate in the bioassay program subsequent to working with radioactive material listed in the table below:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Form</th>
<th>Activity (mCi)</th>
</tr>
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<tbody>
<tr>
<td>I-125, I-131</td>
<td>Unbound</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Bound to a non-volatile agent</td>
<td>10</td>
</tr>
<tr>
<td>H-3</td>
<td>Any compounds</td>
<td>40</td>
</tr>
<tr>
<td>C-14</td>
<td>Any compound</td>
<td>10</td>
</tr>
</tbody>
</table>

- 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 radiiodines. 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, i.e., 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 as a result of 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 Radiation Safety Office 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 gives levels at which prescribed actions are to be taken by the Radiation Safety Office. 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. At the discretion of the RSO, she/he may investigate and/or take action to reduce the exposure. If Level 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.

<table>
<thead>
<tr>
<th>Exposure Type</th>
<th>Regulatory Limit (mrem/year)</th>
<th>Goal (mrem/year)</th>
<th>Level I (mrem/qtr)</th>
<th>Level II (mrem/qtr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Body</td>
<td>5,000</td>
<td>500</td>
<td>125</td>
<td>375</td>
</tr>
<tr>
<td>Lens of the Eye</td>
<td>15,000</td>
<td>1,500</td>
<td>375</td>
<td>1,125</td>
</tr>
<tr>
<td>Skin / Extremity</td>
<td>50,000</td>
<td>5,000</td>
<td>1,250</td>
<td>3,750</td>
</tr>
<tr>
<td>Minors (whole body)</td>
<td>100</td>
<td>50</td>
<td>any positive</td>
<td>30</td>
</tr>
<tr>
<td>Embryos/Fetus</td>
<td>500*</td>
<td>100*</td>
<td>33</td>
<td>100</td>
</tr>
<tr>
<td>Member of Public</td>
<td>100</td>
<td>25</td>
<td>5†</td>
<td>15†</td>
</tr>
<tr>
<td>Member of Public (from released patient)</td>
<td>500</td>
<td>100</td>
<td>25†</td>
<td>75†</td>
</tr>
</tbody>
</table>

* per 9 month gestation period
† based on calculational model

Revised: May 2012
II. G. Pregnant Radiation Workers

State and federal regulations limit the radiation dose to the embryo/fetus of an occupationally-exposed declared pregnant woman to 0.5 rem (500 millirem) for the entire gestation. A declared pregnant woman is defined in the regulations as "a woman who has voluntarily informed the licensee, in writing, of her 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 woman 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 woman has the choice of declaring her pregnancy, thereby imposing a dose limit to her embryo/fetus. To comply with the more restrictive radiation dose limits, the University may require the use of additional protective equipment (e.g., additional shielding, lead aprons), increased monitoring (e.g., extra film badges, pocket dosimeters), 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 woman who wishes to impose radiation dose limits for her 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 (e.g., immediate supervisor) and service providers (e.g., the company providing radiation monitoring service) with a legitimate need-to-know.
- A declared pregnant woman may "undeclare" her pregnancy. The intent of the regulation and this policy is to give the pregnant woman the right to choose whether or not to impose dose limits. She may revoke her choice but her right to choose is irrevocable.
- A pregnant woman may seek recommendations from the Radiation Safety Officer to reduce radiation exposure to her embryo/fetus without declaring her pregnancy.
- Any woman 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 her pregnancy so that the special precautions can be terminated.
- The radiation dose limit to the embryo/fetus of a declared pregnant woman is 0.5 rem (500 millirem). The radiation dose limit applies only to occupational exposure of the declared pregnant woman. It does not apply to radiation exposure from medical diagnosis or treatment.

Summary

If you are pregnant, you have the right to request that a lower dose limit apply to your embryo/fetus. If you choose to make this request, you need to declare your pregnancy to the Radiation Safety Office. If necessary, additional precautions will be provided. You need to contact the Radiation Safety Office when you are no longer pregnant so that these more restrictive precautions can be lifted.
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- 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 woman who plans to declare her pregnancy is encouraged to do so promptly upon discovering her 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 Drexel main campus and Pennsylvania Biotechnology Center.
  - Radiation Safety Office for the Center City campus
- If radioactive materials will be shipped from another institution (from a colleague, from a previous job, etc.), make arrangements through the Radiation Safety Office.

Receiving Radioactive Materials

Upon receipt of radioactive materials the Radiation Safety Office 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.

At the Pennsylvania Biotechnology Center, an individual will be appointed act on behalf of the Radiation Safety Office and perform the receiving of radioactive material functions normally performed by the Radiation Safety Office.

Summary

To order radioactive materials simply submit a purchase requisition to the Radiation Safety Office. The Radiation Safety Office will, in turn, forward it to University Procurement to place the order. Hint: Fax your purchase request to the Radiation Safety Office.
Transfer of Radioactive Materials

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

Transfer of radioactive material to another institution requires Radiation Safety Office assistance 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 Radioactive Materials

The procedures for ordering and 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
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 label. Examples of this equipment include: chemical fume hoods, refrigerators, freezers, radioactive waste containers, dedicated micro-centrifuges, 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,

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.
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II. I. Use and Control of Radioactive Material

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 meter (i.e., Geiger counter) are portable instrument 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 (e.g., on hands) when leaving the laboratory for breaks, lunch, and at the end of the work day. 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 Tests)

Surveys for removable contamination are to be done monthly or after each experiment, whichever is more frequent. For laboratory where experiments are ongoing, surveys, 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, phone, door knobs, 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 be also determined.

The amount of removable contamination shall be recorded in the units of disintegrations per minute (dpm) per 100 cm². The action level for decontamination is 1000 dpm / 100 cm² above background. The action level needs to be listed on the survey form used.

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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 Radiation Safety Office 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: $^{14}$C, $^{32}$P, $^{33}$P, $^{35}$S and other medium to high energy beta emitters. Although a GM survey meter can be used to detect $^{125}$I, $^{99m}$Tc, $^{57}$Co and other isotopes which primarily emit x and gamma rays, a crystal scintillation detector has much higher detection efficiency. $^{3}$H and $^{63}$Ni cannot be detected with standard survey meters. Use a liquid scintillation detector to detect $^{3}$H on wipe samples.

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

<table>
<thead>
<tr>
<th>Radiation Levels</th>
<th>Instrument Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low energy beta radiation ($^{3}$H, $^{63}$Ni)</td>
<td>None</td>
</tr>
<tr>
<td>Moderate - high energy beta radiation ($^{14}$C, $^{35}$S, $^{33}$P, $^{32}$P, $^{90}$Sr)</td>
<td>Thin window (end or pancake) GM detector</td>
</tr>
<tr>
<td>Low energy gamma radiation ($^{125}$I, $^{103}$Pd)</td>
<td>Thin crystal sodium iodide detector</td>
</tr>
<tr>
<td>Moderate - high energy gamma radiation ($^{137}$Cs, $^{60}$Co)</td>
<td>Thick crystal (1&quot; x 1&quot;) sodium iodide detector</td>
</tr>
<tr>
<td>Radiation levels (i.e., dose rates)</td>
<td>Ion chamber survey meter</td>
</tr>
</tbody>
</table>
II. I. Use and Control of Radioactive Material  
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 must be documented. The Radiation Safety Office uses this information to maintain an inventory for the entire University; therefore, authorized users need to submit reports of the use of radioactive materials to the Radiation Safety Office 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 of tobacco products is NOT permitted.
- Do not store foodstuff for human consumption in the laboratory.
- Mouth pipetting is NOT permitted.
- Wear 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 area.
- 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 (hands, body, feet) and work area before leaving the laboratory for lunch breaks and at the end of the day; and after each high level use (e.g., aliquotting from stock solution) of radioactive material.
- Follow the procedures for receiving radioactive material packages.
- Use acrylic shielding where practical and appropriate when manipulating $^{32}\text{P}$.
- 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.
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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 secured from unauthorized removal at all times. 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/hr 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 Radiation Safety Office 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 Radiation Safety Office 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,
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- 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 Radiation Safety Office 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 Radiation Safety Office prior to departure of the source to allow the Radiation Safety Office to inventory and leak test the source.
- Provide the Radiation Safety Office with the name of the Radiation Safety Officer at the site that the source is being shipped.
- Ensure that a leak test kit is included in the source shipment in the event that 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 Radiation Safety.

Sealed Source Inventory

The Radiation Safety Office 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 Radiation Safety Office 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.

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

Disposal Methods and Procedures for Animal Carcasses

Decay in Storage

Animal carcasses containing radioactive materials with half lives less than 120 days may be stored for disposal by radioactive decay. Double bag carcasses, label the bag with the isotope, approximate activity, radiation warning label, and 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.

Commercial Waste Disposal

Double bag carcasses, label the bag with the isotope, approximate activity, radiation warning label, and 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 Radiation Safety Office will arrange for commercial disposal at the next scheduled waste removal.

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 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

Decay in Storage

Solid dry radioactive waste containing isotopes with half lives 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 thick (4 mil) polyethylene bag. If the waste contains biologically active material that needs to be disposed as a biohazard waste in addition to its radioactivity, use a biohazard bag. Label the bag with a radiation label, and complete and attach a waste tag to the bag. The Radiation Safety Office will store the waste and dispose of it after it has decayed to background levels.

Commercial Waste Disposal

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

Note: Sealed sources should be segregated from contaminated laboratory trash.
Disposal Methods and Procedures for Liquid Scintillation Fluids

Decay in Storage

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

Commercial Waste Disposal

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

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 Radiation Safety Office will arrange for disposal of these; therefore, follow the instructions for commercial disposal.

Sink Disposal

Sink disposal is permitted if the chemical form of the liquid scintillation fluid permits disposal into the sewer. Follow the sink disposal procedures listed in the aqueous liquid disposal section below.
Disposal Methods and Procedures for Aqueous and Organic Liquids

Sewer Disposal

Sewer disposal of radioactive materials are regulated based on the radioactive properties and the chemical properties of the material to be disposed.

Each authorized user utilizing sewer disposal must be specially approved for disposal in a designated sink within the laboratory. Each designated sink is to be outlined in radioactive tape and the sink disposal limits 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 thorough 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 Chemical Safety Officer for advice.

Decay in Storage

Liquid waste containing isotopes with half lives less than 120 days may be disposed by decay in storage. Segregate liquid waste by isotope for efficient decay in storage disposal. Place the waste in an unbreakable container, label the container with a radiation label, and complete and attach a waste tag to the container. The Radiation Safety Office will store the waste and dispose of it after it has decayed to background levels.

Commercial Waste Disposal

Liquid fluids containing isotopes with half-lives greater than 120 days that cannot be disposed into the sink may be disposed commercially after the waste is solidified. Contact the Radiation Safety Office to make arrangements for solidification and disposal.
II. N.  Emergency Procedures

Reporting and Investigating Radiation Incidents

In 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 that cannot be categorized thusly must be reported to the Radiation Safety Office promptly.

Minor Spills

If all of the following are true, an incident can be considered minor:

- The nature and potential hazards are known
- There is no contamination of personnel
- One or two people can clean up the incident in about an hour
- There is no release of radioactive material into unrestricted areas
- There is no airborne radioactive material
- There are no injuries (e.g., lacerations from broken glass) except where radioactive material is not involved and medical attention is not required
- There is no potential uptake of radioactive material

In the event of a minor spill take the following steps:
1. **Notify** all other persons in the room or area that a spill has occurred.
2. **Prevent spread of contamination** by covering the spill with absorbent paper.
3. **Decontaminate** the area. Using paper towels or absorbent pads, clean towards the center of the spill. Place all waste into plastic bag and dispose as radioactive waste. Disposable gloves, lab coat, and if appropriate, shoe covers should be worn. Cleansing agents may be used after initial decontamination attempt.
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 Radiation Safety Office by telephone.

Major Spills

If any of the following are true, an incident should be considered major:

- The nature or potential hazard cannot be ascertained
- Personal contamination (skin or clothing; contamination of personal protective equipment, e.g., lab coats is not personal contamination)
- The cleanup will take more than two people or more than an hour to perform.

A spill is defined as leaving the confines of the experiment. Therefore, a discharge onto absorbent paper or a drip tray is not a spill.
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- There is a release of radioactive material into unrestricted areas.
- Airborne radioactive material is generated.
- Injuries which might involve radioactive material (e.g., laceration from contaminated glass)
- 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:
1. **Clear the area**: notify all persons not involved with or near the spill to vacate the room.
2. **Prevent 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**: prevent entry into the room.
4. **Call for help**: Immediately contact Radiation Safety.
5. **Decontaminate personnel**: Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by Radiation Safety. Contaminated skin should be flushed thoroughly with lukewarm water and then washed with mild soap and lukewarm water.

**Fires**

In the event of a fire in a laboratory, follow RACE procedures:
1. **Rescue** persons in immediate danger
2. **Alarm** - activate manual pull station and call Security with the fire location.
3. **Contain** the fire by closing the room.
4. **Evacuate** the area. Do not attempt to extinguish the fire unless:
   a) The fire presents an immediate risk of injury to you or someone else in the area; or
   b) The fire is very small in size, easily extinguished, and you have had fire extinguisher training.

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.

All incidents along with RSO assessment will be reported to the Radiation Safety Committee.
II. O. Enforcement Policy

The purpose of this policy is to create and implement procedures to deal with issues of non-compliance. 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 Radiation Safety Office.

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

<table>
<thead>
<tr>
<th>Level</th>
<th>Violation</th>
<th>Enforcement Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Items which are of an immediate threat to health and safety, e.g., production of airborne radioactive material in the laboratory.</td>
<td>Immediately shut down lab, revoke the individual's license and remove radioactive materials from the premises for storage by the Radiation Safety Office.</td>
</tr>
<tr>
<td>Level 2</td>
<td>Items which pose a threat to health, safety or which could result in civil penalties against the University. e.g., using unlicensed materials, unrestricted access to radioactive materials.</td>
<td>Give notice to the researcher that his/her 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 individual 48 hours to respond to the situation.</td>
</tr>
<tr>
<td>Level 3</td>
<td>Items which have the potential for significant threat to health, safety, and compliance, e.g., performing unauthorized experiments.</td>
<td>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.</td>
</tr>
<tr>
<td>Level 4</td>
<td>Items which, individually have only a minor affect on health and safety, but if continued could significantly affect compliance, health, or safety, e.g., missing a survey, failure to record survey.</td>
<td>Give the researcher notice as to the nature of the violation. Give the individual 30 days time in which to rectify the situation.</td>
</tr>
<tr>
<td>Level 5</td>
<td>Minor paperwork which has little bearing on health, safety or compliance, e.g., copy of Form 3 posted in lab, copy of manual in lab.</td>
<td>Provide authorized user with the materials necessary to comply with policy.</td>
</tr>
</tbody>
</table>
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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 Radiation Safety Office 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 assure 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 in:
  - Specifically designated laboratories and
  - Specifically designated exhaust hood by
  - Specifically authorized individuals.

- Exhaust hoods to be used must be or must have:
  - Unless deemed unnecessary by the Radiation Safety Officer, an air sampling system must be in place to sample effluents released.
  - Face velocities greater than 75 ft/min and less than 120 ft/min. Velocities to be checked annually by Drexel University Department of Environmental Health and 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 relatively 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 Radiation Safety Office. The Radiation Safety Office 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)
  - Survey meter is present and operational. Ideally the following would be available for use:
    - $^{125}$I – Crystal scintillation detector (available on loan from the Radiation Safety Office)
    - $^{131}$I – GM (end window or pancake) detector
  - Exhaust hood window is kept as low as consistent with the proper performance of the exhaust hood and the iodination procedure.
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- At least 2 layers of gloves, a lab coat, and assigned dosimeter are worn during the iodination.

- After iodination:
  - Turn off air sampling system and record the time and the air flow volume rate.
  - Record the duration of the iodination in minutes.
  - Call Radiation Safety Office to recover filter for effluent measurement.
  - Arrange for thyroid uptake bioassays.
  - Clean up the exhaust hood.
  - Thoroughly survey the entire area including floors, hood, equipment, outer waste container 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 Your Laboratory

Follow procedures for use of RAM as listed in this manual and as specified in your authorization to use radioactive materials. Dispose of sacrificed 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 room 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 Radiation Safety Office if you need assistance.

Remove radioactive waste and transfer to the Radiation Safety Office.

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 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 women 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.

### Definition

**Routine diagnostic or therapeutic procedure.** A clinically-indicated, standard-of-care diagnostic or therapeutic procedure routinely performed on patients with the condition indicating the 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.
Procedures for approval is dependent on the particular 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 assure 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.

Inter-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.

Examples

Class 1:
- Baseline and follow-up CT scan for subjects treated for cancer.
- External beam radiation therapy for treatment of lung cancer where protocol involves a new chemotherapeutic drug cocktail.
- Cardiac stress test for subjects with unstable angina.

Class 2:
- Follow-up CT scans more frequent than standard of care.
- MUGA scan following treatment with research drug that is potentially cardiotoxic.
- Baseline and follow-up chest x-ray for a clinical trial involving a new asthma treatment regimen.

Class 3:
- New radiolabeled monoclonal antibody for treatment of melanoma
- Four per day fractionated external beam therapy.

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

You will be exposed to a small amount of radiation from the chest x-rays. These x-rays would not normally be performed as a part of your standard medical care had you not participated in this research project. The amount of radiation from the chest x-rays is unlikely to cause any harmful effect.

This research study involves exposure to radiation from a chest x-ray 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 a chest x-ray. Chest x-rays 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 a 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 a 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.

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<th>Typical Doses</th>
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<tr>
<td>DEXA - whole body scan</td>
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<td>Skull (PA or AP)</td>
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<td>Bitewing Dental</td>
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</table>
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- 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.

- 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.
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 Radiation Safety Office 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 Radiation Safety Office 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 Users’ 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 Radiation Safety Office.

Before using an irradiator, all persons must be trained by the authorized user (or his/her 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
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- Observation of an irradiation procedure
- Performance of an irradiation procedure under the supervision of a trained operator

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 for 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 Radiation Safety Office 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.

Revised: May 2012
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 Radiation Safety Office 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 Radiation Safety Office.

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 is capable of causing serious, permanent radiation damage if the inherent shielding has been compromised. Of primary concern are fingers when manipulating targets. Under normal circumstances, 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.
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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 a distance of 5 centimeters from the housing surface.

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 insure their proper operation. (A copy of the survey forms are 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.
- 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 personnel 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 Radiation Safety Office whenever any of the above conditions occurs so that a survey can be performed.

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 Radiation Safety Office 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 actually occurred.

**Open Beam Systems**

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:
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- 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 of 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 the radiographic exposure.
- Provide protective garments (lead aprons/shielding) for everyone whose presence is necessary during the 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.

State of Pennsylvania Regulation

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 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 Radiation Safety Office 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.
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**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
- Individuals(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.

Hint

Some consumer products contain radioactive materials and can be used for demonstration purposes. Examples include:
- Orange vintage Fiestaware (uranium-238)
- Salt substitutes (potassium-40)
- Vaseline glass (uranium-238)
- Certain welding rods (thorium-232)
- Some gas lantern mantles (thorium-232)
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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.

Sponsor/supervisor of minor will notify Radiation Safety Office in writing of each minor with the following information:

- Name of minor
- Affiliation of minor with the University
- Period of time minor will work with source of radiation
- Description of students’ activities with sources of radiation
- Confirmation that 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 Radiation Safety Office for use of 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.
How to become an authorized user
How to order radioactive materials
How to receive a radioactive package
How to request a radiation monitoring badge
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 Radiation Safety Office 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.
   
   Hint #1: Fax the requisition to 215-762-1608 or e-mail a scanned copy of the requisition to radiationsafety@drexel.edu.

   Hint #2: 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.

Here is what happens while you wait:

3.a. Radiation Safety reviews the purchase requisition to assure that the lab is authorized to possess the requested radioactive material.

3.b. Radiation Safety faxes the approved purchase requisition to University Procurement.

3.c. University Procurement reviews the purchase requisition to assure that funding is available, etc.

3.d. University Procurement places the order.

3.e. Radiation Safety receives notice of the order and tracking information for the package.

3.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.)

3.g. Radiation Safety checks the package for damage and for external contamination.

3.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.
If you are using radioactive materials or radiation producing machines, please complete the Radiation Worker Registration form and submit it to the Radiation Safety Office. The Radiation Safety Office will use this to determine whether to provide radiation monitoring.

Generally, 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:

<table>
<thead>
<tr>
<th>Annual Dose Limit (mrem)</th>
<th>Monitoring Required (mrem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult whole body</td>
<td>5,000</td>
</tr>
<tr>
<td>Extremity</td>
<td>50,000</td>
</tr>
<tr>
<td>Fetus (per gestation)</td>
<td>500</td>
</tr>
<tr>
<td>Minor whole body</td>
<td>500</td>
</tr>
</tbody>
</table>

Drexel University and the College of Medicine choose 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 too weak to be measured. No monitoring provided |
| High energy beta emitters: e.g., $^{32}$P, $^{90}$Sr/$^{90}$Y, $^{86}$Rb | Manipulation of $>1$ mCi at any time. Extremity (finger/hand) monitoring |
| Unshielded photon emitters | Manipulation of $>0.1$ 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. |
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 Radiation Safety Office – 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 Radiation Safety Office for the most recent version of these forms.
# Radiation Worker Registration

## Identification
- **Name**: First M I Last
- **Gender**: M F
- **Last 4 digits of SSN**: Birthdate
- **Title/Position**: Phone: Fax:

## Location
- **Department**: Drexel University
- **Supervisor / PI**: Wills Eye Institute
- **Employer**: Drexel University
- **Building**: St. Christopher's Hospital
- **Other**: Eastern Regional Medical Ctr
- **Room**: Other:

## Involvement With Radiation Sources
- **Unsealed radioactive material**: Isotope mCi Isotope mCi
- **Sealed radioactive sources**: Isotope mCi Isotope mCi
- **Device containing radioactive sources**: Irradiator HDR Other:
- **X-ray producing machine(s)**: SEM TEM XRD Radiographic Fluoro 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**: Provider:
- **Course**: Provider:

## Experience - Check all that best describe your experience with sources of radiation
- **Sealed sources**: 
- **Unsealed sources**: 
- **Research lab**: 
- **Clinical uses**: 

## 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**: Body Ring Facility Location
- **Bimonthly**: Collar Fetal Participant No
- **Quarterly**: Waist Other: Date Issued
**DREXEL UNIVERSITY**
**DREXEL UNIVERSITY COLLEGE OF MEDICINE**

Application for Possession and Use of Radioactive Materials in Basic Research

### Identification

<table>
<thead>
<tr>
<th>Name</th>
<th>First</th>
<th>MI</th>
<th>Last</th>
<th>Suffix</th>
<th>Degree (MD, Ph.D.)</th>
</tr>
</thead>
<tbody>
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<table>
<thead>
<tr>
<th>Department</th>
<th>Faculty Appointment:</th>
</tr>
</thead>
<tbody>
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</table>

<table>
<thead>
<tr>
<th>E-mail</th>
<th>Phone:</th>
<th>Fax:</th>
</tr>
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</table>

### Location

<table>
<thead>
<tr>
<th>Employer</th>
<th>Drexel University</th>
<th>Drexel College of Medicine</th>
<th>Campus</th>
<th>Center City</th>
<th>Queen Lane</th>
</tr>
</thead>
<tbody>
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</table>

<table>
<thead>
<tr>
<th>Office</th>
<th>Building</th>
<th>Room</th>
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<tbody>
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</tbody>
</table>

### Radioactive Material

#### Radionuclide 1

- **Chemical Form:**

<table>
<thead>
<tr>
<th>Physical Form</th>
<th>gas</th>
<th>liquid</th>
<th>sealed source</th>
<th>plated source</th>
<th>other solid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

For sealed or plated source: Mfg/model:

Device mfg/model:

For other solid describe source (e.g., powder, activated metal):

Activity per order: microcuries

Order frequency: per week

Activity per experiment: microcuries

Experiment frequency: per day

Maximum amount in lab at one time (including in waste): microcuries

#### Radionuclide 2

- **Chemical Form:**

<table>
<thead>
<tr>
<th>Physical Form</th>
<th>gas</th>
<th>liquid</th>
<th>sealed source</th>
<th>plated source</th>
<th>other solid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

For sealed or plated source: Mfg/model:

Device mfg/model:

For other solid describe source (e.g., powder, activated metal):

Activity per order: microcuries

Order frequency: per week

Activity per experiment: microcuries

Experiment frequency: per day

Maximum amount in lab at one time (including in waste): microcuries

#### Radionuclide 3

- **Chemical Form:**

<table>
<thead>
<tr>
<th>Physical Form</th>
<th>gas</th>
<th>liquid</th>
<th>sealed source</th>
<th>plated source</th>
<th>other solid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

For sealed or plated source: Mfg/model:

Device mfg/model:

For other solid describe source (e.g., powder, activated metal):

Activity per order: microcuries

Order frequency: per week

Activity per experiment: microcuries

Experiment frequency: per day

Maximum amount in lab at one time (including in waste): microcuries
Methods/Procedures

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

Radiosotope 1:

Have you performed these procedures previously:  [ ] yes  [ ] no

Radiosotope 2:

Have you performed these procedures previously:  [ ] yes  [ ] no

Radiosotope 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 tri-phosphates.
### Equipment and Facilities

<table>
<thead>
<tr>
<th>Location</th>
<th>List building(s) and room(s) where radioactive material will be used or stored, and the room use, e.g., counting, storage, laboratory.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus</td>
<td>Building</td>
</tr>
<tr>
<td>Main</td>
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<tr>
<td>Main</td>
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<tr>
<td>Main</td>
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<td>Main</td>
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</tbody>
</table>

### Analytical Radiation Detection Equipment
List the type (liquid scintillation counter, gamma counter, etc.), manufacturer, model number (if known), and location of any analytical equipment used with this protocol.

<table>
<thead>
<tr>
<th>Type</th>
<th>Mfg. &amp; Model No.</th>
<th>Location</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

### Portable Radiation Survey Instruments
List the type(s), manufacturer and model number(s) of survey meters available in the facility.

<table>
<thead>
<tr>
<th>Manufacturer &amp; Model No.</th>
<th>Instrument / Probe Type</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

### Radioactive Waste
Indicate the types of waste and the disposal category that will be generated.

<table>
<thead>
<tr>
<th>Storage for Decay</th>
<th>Liquid Scintillation Fluids</th>
<th>Animal Carcasses</th>
<th>Sealed Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half-life &lt; 3 days</td>
<td>Toluene/Xylene</td>
<td>Non-flammable</td>
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</table>

Estimate the volume of waste generated annually:

- Solids & liquids stored for decay: [ ] Liters
- Off-site disposal: [ ] Small (5 gal, 0.7 cf) pails  [ ] Liquid scintillation fluids  [ ] 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: [ ] microcuries
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.

<table>
<thead>
<tr>
<th>Formal and On-The-Job Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topics</td>
</tr>
<tr>
<td>Principles of radiation protection</td>
</tr>
<tr>
<td>Measurement / monitoring techniques and instruments</td>
</tr>
<tr>
<td>Calculations applicable to radioactivity (e.g., half-life decay)</td>
</tr>
<tr>
<td>Biological effects of radiation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Experience with Radioactive Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radionuclides</td>
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<tr>
<td>----------------</td>
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</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Registered as a Radiation Worker</th>
<th>Initial radiation safety instructions provided by PI</th>
<th>Attended Radiation Safety Short Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

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 for training of all radioactive 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: ____________________________

☐ My name in the signature space above signifies my signature on this document.
<table>
<thead>
<tr>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>First:</td>
</tr>
<tr>
<td>MI:</td>
</tr>
<tr>
<td>Last:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radioactive Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radionuclide 1</td>
</tr>
<tr>
<td>Chemical Form:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Form:</th>
</tr>
</thead>
<tbody>
<tr>
<td>gas</td>
</tr>
<tr>
<td>liquid</td>
</tr>
<tr>
<td>sealed source</td>
</tr>
<tr>
<td>plated source</td>
</tr>
<tr>
<td>other solid</td>
</tr>
</tbody>
</table>

| For sealed or plated source: |
| Mfg/model:                  |
| Device mfg/model:           |

| For other solid describe source (e.g., powder, activated metal): |

<table>
<thead>
<tr>
<th>Activity per order</th>
<th>microcuries</th>
<th>Order frequency</th>
<th>per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity per experiment</td>
<td>microcuries</td>
<td>Experiment frequency</td>
<td>per day</td>
</tr>
</tbody>
</table>

| Maximum amount in lab at one time (including in waste): |
| microcuries |

Describe the laboratory procedures.

Have you performed these procedures previously: □ yes □ no
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. 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 tri-phosphates.

Signature: __________________________ Date: ____________

□ My name in the signature space above signifies my signature on this document.
### Authorized User Identification

Name: **First** | **Mi** | **Last**

### Radioactive Material Type and Quantity

Radionuclide: 
Chemical compound: 
Activity administered per animal: **microcuries**

Number of animals administered radioactive material: 
Number of administrations per animal: 

### Administration to Animals

Animal species (e.g., rat, mouse): 

Describe administration method (e.g., IV injection into tail vein): 

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 (e.g., biological half-time): 

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 
- 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? **hours**  
- n/a

Animals will be moved to:  
- Animal facility  
- Other: 

How much radioactive material will remain in each animal when moved? **microcuries**
Animal Care and Precautions

Who will care for animals after administration? □ Animal facility staff □ Lab staff □ n/a (i.e., animals sacrificed)

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

How will these animals be identified as radioactive?

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

Describe procedures cleaning / decontaminating cages:

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

Describe procedure 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 IACUC approval?

- □ Not submitted
- □ Submitted, pending committee action
- □ Approved pending Radiation Safety approval
- □ Approved with pending conditions
- □ Rejected.

Signature: ___________________________ Date: ___________________________

□ My name in the signature space above constitutes my signature on this document.
**Amendment to Existing Authorization**
**For Use of Radioactive Materials**

Radiation Safety Office

Name of Authorized User: 

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) mCi
   
   (b) Isotope: 
   
   Activity: mCi
   
   Chemical Form:
   
   Sink disposal limit for above isotope (default is 10% of possession limit) mCi

2. **Possession Limits Change** *provide reason for increase in Section 4*
   
   Isotope: Current Limit mCi Proposed Limit mCi
   
   Isotope: Current Limit mCi Proposed Limit mCi
   
   Isotope: Current Limit mCi Proposed Limit mCi

3. **Sink Disposal Limit Change** *provide reason for increase in Section 4*
   
   Isotope: Current Limit mCi/month Proposed Limit mCi/month
   
   Isotope: Current Limit mCi/month Proposed Limit mCi/month
   
   Isotope: Current Limit mCi/month Proposed Limit mCi/month
Amendment to Existing Authorization  
For Use of Radioactive Materials

4. New Procedure

Describe specific procedures proposed.

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

Signature: ___________________________  Date: ___________________________

☐ Name typed in signature block acts 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 worker) 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 Radiation Safety Office Use Only

Dose registered to date ________________________________ mR.

Action taken:

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________
RADIOACTIVE MATERIAL RECEIPT AND SURVEY FORM

Order

Authorized User Location
(Room and Building):

Isotope: Activity: □ μCi □ mCi

Vendor: Catalog Number:

Isotope and activity agree with order: □ Yes □ No

Package Receipt

Date Received: Package ID Number: Isotope and activity agree 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 □ Radioactive Yellow II □ Radioactive Yellow III

If labeled: wipe all external surfaces (at least 300 cm²) with a filter paper, count in appropriate counter, calculate activity

<table>
<thead>
<tr>
<th>Counting Instrument</th>
<th>Wipe (cpm)</th>
<th>(3) Bkgd. (4)</th>
<th>(4) Net cpm (2) (3)</th>
<th>(5) Efficiency (6) dpm (4)(5)</th>
<th>(7) Area Wiped (cm²)</th>
<th>(8) dpm per 100 cm²</th>
<th>[16)(17) x 100</th>
</tr>
</thead>
</table>

***If removable activity exceeds 2200 dpm/100 cm², contact the Radiation Safety Officer immediately.***

If not labeled: wipe all external surfaces 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-source sources)

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

Package Delivery to Laboratory

<table>
<thead>
<tr>
<th>Package</th>
<th>Received By</th>
<th>Date</th>
<th>Received</th>
</tr>
</thead>
</table>

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 215-762-1608.

Internal Package Survey

Packing slip and vial contents agree: Radiomuclide □ Yes □ No Activity □ Yes □ No Chemical □ Yes □ No

Vial integrity intact □ Yes □ No

If any answer is no, contact Radiation Safety Office

Disposition of Package / Packing Material

□ Package and packing material free of contamination(<200 dpm/100 cm²), 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.

Revised February 5, 2013

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.

<table>
<thead>
<tr>
<th>Location(s)</th>
<th>Dose Rate (mR/hr)</th>
<th>Background (mR/hr)</th>
<th>Survey Instrument Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
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<td>2.</td>
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<td>3.</td>
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<tr>
<td>4.</td>
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<tr>
<td>5.</td>
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</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>A.</td>
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<td>B.</td>
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<tr>
<td>C.</td>
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<td>D.</td>
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<td>E.</td>
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</tbody>
</table>

Instrument ID

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma Counter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Scintillation Counter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Room Diagram

This form to be retained in your files. Call the Radiation Safety Office if contamination >1000 dpm/100 cm² or if unexpected radiation levels (e.g., >2 mR/h in unrestricted areas) are found.

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.
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.

<table>
<thead>
<tr>
<th>Date</th>
<th>Isotope</th>
<th>Amount</th>
<th>Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Send this form in with the quarterly inventory report.
Radiation Emergency Instructions

MINOR SPILLS* involving no radiation hazard to personnel.

1. Notify all other persons in the room or area that a spill has occurred.
2. Prevent spread of contamination by covering the spill with absorbent paper.
3. Decontaminate the area. Using paper towels or absorbent pads, clean towards the center of the spill. Place all waste into plastic bag and dispose as radioactive waste. Disposable gloves, lab coat, and if appropriate, shoe covers should be worn. Cleansing agents may be used after initial decontamination attempt.
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 Radiation Safety Office 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 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: prevent entry into the room.
4. Call for help: Immediately contact Radiation Safety.
5. Decontaminate personnel: Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by Radiation Safety. Contaminated skin should be flushed thoroughly and then washed with mild soap and lukewarm water.

FIRES

1. Rescue persons in immediate danger
2. Alarm - activate manual pull station and call Security with the fire location.
3. Contain the fire by closing the room.
4. Evacuate the area. Do not attempt to extinguish the fire unless:
   a) The fire presents an immediate risk of injury to you or someone else in the area; or
   b) The fire is very small in size, easily extinguished, and you have had fire extinguisher training.

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 Radiation Safety can be reached at the following numbers:

Main Number: 215-762-4050
RSO Staff: 762-3411, 762-6494

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

*A spill is defined as leaving the confines of the experiment. A discharge onto absorbent paper or a drip tray is not a spill.
Quarterly Radionuclide Inventory and New Staffing Report

Authorized User:  
Reporting Period:  
Year  

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.

<table>
<thead>
<tr>
<th>Radionuclide(s)</th>
<th>+</th>
<th>+</th>
<th>+</th>
<th>+</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity on hand at beginning of quarter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity received during quarter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity transferred to others during quarter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity given to Radiation Safety as waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity disposed down drain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decay losses**</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**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.**

<table>
<thead>
<tr>
<th>Name</th>
<th>Registered</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

RSO Use Only

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:**

$$\text{Decay Loss} = A_0 \left(1 - e^{-\frac{t}{\text{half-life}}}\right)$$

where \(A_0\) 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 ___________________________ Title ___________________________

first last 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/100 cm²
☐ Proper spill and clean up procedure and notification of RSO.
☐ Proper waste management of radioactive materials (sink disposal and solid waste).
☐ 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: ___________________________

Revised 2/9/2011
Audit Forms

Used by the Radiation Safety Office

For Information Only
### 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

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Warning devices are labeled so that their purpose is easily identified.</td>
<td>[§§227.11a(c)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Equipment has fail-safe characteristics.</td>
<td>[§§227.11a(b)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td>[§§227.11a(d)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Unused ports on radiation source housings shall be secured in the closed position in a manner which will prevent casual opening.</td>
<td>[§§227.11a(e)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Unit is labeled with a readily discernible sign bearing the radiation symbol and (a) “Caution—High Intensity X-Ray Beam” or similar wording on the X-ray source housing, and (2) “Caution Radiation—This Equipment Produces Radiation When Energized,” or similar wording, near any switch that energizes an X-ray tube.</td>
<td>[§§227.11a(f)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Safety and warning devices (e.g., interlocks, warning lights) operate properly.</td>
<td>[§§227.12a(c)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device: ________________  Test: ________________</td>
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<tr>
<td>Device: ________________  Test: ________________</td>
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<td>Device: ________________  Test: ________________</td>
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<td>Device: ________________  Test: ________________</td>
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</tbody>
</table>

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#### Radiation Levels and Surveys

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>[§§227.12a(b)]</td>
<td></td>
<td></td>
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<tr>
<td>Radiation Detector used: Mfg: ___________  s/n: ___________  Cal. Date: ___________</td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 The leakage radiation is less than 0.5 mR/hour at 5 cm from the surface of the x-ray generator housing.</td>
<td>[§§227.12a(b)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
<td></td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Radiation levels in any area surrounding local components will not result in a dose to an individual over 100 mrem.</td>
<td>[§§227.12a(c)]</td>
<td></td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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<tr>
<td>Location: ________________  Dose rate: ________ mR/h</td>
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<td></td>
<td>Surveys are performed:</td>
<td>Yes</td>
<td>No</td>
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<td>------------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td>(a) annually</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td></td>
<td>(b) Following a change in the initial arrangement, number or type of local components*</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td></td>
<td>(c) Following maintenance requiring the disassembly or removal of a local component*</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>(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.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>(e) When a visual inspection of the local components* reveals an abnormal condition.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>(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.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>(g) When the machine is operated in a manner other than the routine manner specified in the operating procedures.</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

*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 supplies, transformers, amplifiers, readout devices and control panels. [§§227.12(a)(d)]

<table>
<thead>
<tr>
<th></th>
<th>Operating Procedures</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Written operating procedures are available to the analytical X-ray equipment operators.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13</td>
<td>Operating procedures include instructions for:</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>(a) sample insertion and manipulation,</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td></td>
<td>(b) equipment alignment,</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td></td>
<td>(c) routine maintenance and</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>(d) data recording procedures which are related to radiation safety.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

[§§227.13(a)(b)]

<table>
<thead>
<tr>
<th></th>
<th>Unit is not operated in a manner other than that specified in the operating procedures OR</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Written approval from the radiation safety officer has been granted.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15</td>
<td>Safety devices have not been bypassed or otherwise circumvented except as with the prior written approval of the radiation safety officer.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>Administrative controls and procedures to assure the radiation safety of individuals working around the system have been established.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>The bypass of the safety device is not more than 30 days</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>A readily discernible sign bearing the words “SAFETY DEVICE NOT WORKING,” or words containing a similar warning, is placed on the radiation source housing.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

[§§227.13(a)(b)]

|   | Operations involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators or beam stops are not performed, UNLESS the tube is off and remains off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs. | ☐   | ☐  | ☐   |

[§§227.13(a)(c)]

|   | Written emergency procedures are posted near the equipment which lists the names and telephone numbers of personnel to contact. | ☐   | ☐  | ☐   |
|   | The emergency procedures provide information necessary to de-energize the equipment, such as location and operation of the power supply or circuit breakers. | ☐   | ☐  | ☐   |

[§§227.13(a)(d)]
<table>
<thead>
<tr>
<th>Training and Monitoring</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 Individuals operating or maintaining the unit have received instructions in and demonstrated competence as to:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Identification of radiation hazards associated with the use of the equipment.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Written operating and emergency procedures for the equipment.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Symptoms of an acute localized radiation exposure.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Procedures for reporting an actual or suspected exposure.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Use of survey and personnel monitoring equipment.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) The applicable regulations of this article and those incorporated by reference.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 A qualified expert has reviewed reported dose values for the purpose of determining compliance with 10 CFR 20.1201.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Special Requirements for Open Beam Systems</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 If no, has an exemption from the requirement of a safety device been granted?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 A readily discernible indication of:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) X-ray tube status (on-off) located near the radiation source housing (if the primary beam is controlled in this manner) and/or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Shutter status (open-closed) located near each port on the radiation source housing (if the primary beam is controlled in this manner).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Audit performed by: __________________________

Reviewed by: __________________________

Kent Lambert, M.S., CHP
Radiation Safety Officer
### Cabinet X-ray Units
#### Audit and Survey Form

<table>
<thead>
<tr>
<th></th>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
<th>n/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>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 over 10 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</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2</td>
<td>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)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3</td>
<td>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)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4</td>
<td>Each access panel has at least one safety interlock §1020.40(c)(4)(ii)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5</td>
<td>A control must be activated to resume x-ray generation following interruption by an interlock §1020.40(c)(4)(iii)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6</td>
<td>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)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7</td>
<td>X-ray generation is not possible when the key to the key-actuated control is removed §1020.40(c)(4)(v)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8</td>
<td>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)(4)(vi)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9</td>
<td>(a) Two independent means indicate when and only when x-rays are being generated (b) Discriminable 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 milliampere meter labeled to indicate x-ray tube current. (e) All other indicators legible labeled “X-RAY ON” (f) One “X-RAY ON” indicator is visible from each door, access panel, and port §1020.40(c)(4)(vii)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10</td>
<td>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)(4)(viii)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11</td>
<td>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)(4)(ix)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12</td>
<td>Manufacturer’s operating manual(s) and instructions are available. §1020.40(c)(9)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td></td>
<td>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)</td>
<td>Yes</td>
<td>No</td>
<td>n/a</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
</tr>
</tbody>
</table>
|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: __________________________ | □   | □  | □  |

Comments:

Audit performed by: ________________

Reviewed by:  
Kent Lambert, M.S., CHIP  
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

<table>
<thead>
<tr>
<th></th>
<th>Radiation levels measured 5 centimeters from accessible surfaces of the electron microscope did not exceed 0.5 mR/h. (25 PA Code 227.32)</th>
</tr>
</thead>
</table>
| 1 | Background reading: ___________ mR/h  
|   | Measured radiation level ___________ mR/h                                                                                      |
|   | Electron microscope settings: ___________ kV ___________ mA  
|   | Other: ___________                                                                                                               |
|   | Radiation detector used: Mfg: ___________ s/n: ___________ Cal. Date: ___________                                                     |

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Electron microscope is labeled with a readily discernible sign bearing the words, “Caution Radiation—This Equipment Produces Radiation When Energized,” or words containing a similar warning. (25 PA Code 227.31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Operators have been trained and understand the operating procedures necessary to insure radiation safety. (25 PA Code 227.33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Operators have received a copy of the operating procedures. (25 PA Code 227.33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

---

**Survey/Audit Performed by:**  
<select one>  

**Reviewed by:**  
Kent Lambert  CHP  
Radiation
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:

<table>
<thead>
<tr>
<th>High Voltage (kVp)</th>
<th>Tube Current (mA)</th>
<th>Field Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>inches × inches</td>
</tr>
</tbody>
</table>

Scattering Phantom Description: __________________________

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

<table>
<thead>
<tr>
<th>Exposure Time (s)</th>
<th>Measured Dose (µR)</th>
<th>Energy Correction Factor</th>
<th>Dose per Exposure (µR)</th>
<th>Exposures per week</th>
<th>Dose per week @ 1 meter (µR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<td>3</td>
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<td>4</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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 ≥ 1/4 inch lead; maximum kVp and mA.

<table>
<thead>
<tr>
<th>Location</th>
<th>High Voltage (kVp)</th>
<th>Tube Current (mA)</th>
<th>Exposure Time (s)</th>
<th>Measured Dose (µR)</th>
<th>Dose Rate (mR/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Audit

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

**Comments:**

---

Audit performed by: ______________________

Reviewed by: ______________________

Kent Lambert, M.S., CHP
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.

<table>
<thead>
<tr>
<th>I. Signage (R/A Materials Signs)</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerators/Freezers/Cabinets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposal sink(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

<table>
<thead>
<tr>
<th>II. Postings</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current PA State posting (dated 8/2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain disposal sink limits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain disposal sink disposal chart</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Laboratory Radiation Safety Instructions and Emergency Instructions</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:
<table>
<thead>
<tr>
<th>III. Records</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorization Document</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Radiation Safety Manual</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Receipt of shipment records</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Disposition of Material Records</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Quarterly Inventory</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Wipe Test Records&lt;sup&gt;6&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Number of points wiped sufficent</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>B. Performed after every experiment or once a month, whichever is more frequent</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>C. Results expressed in dpm/100 cm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>D. Action level of 1000 dpm/100 cm&lt;sup&gt;2&lt;/sup&gt; listed on survey form</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>E. Evidence of contamination/clean-up</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Comments:**

<table>
<thead>
<tr>
<th>IV. Radiation Detection Equipment</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection equipment available:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mfg ___ Ludlum ___ Model # ___ S/N 222398 ___ Detector type: 44-7___</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Mfg ___ Ludlum ___ Model # ___ S/N 222443 ___ Detector type: 44-9___</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Meter has check source</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Meter operates properly (battery check satisfactory, detects radiation)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Meter calibrated within past year or labeled “For detection only”</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Meter adequate to measure radioactive materials in use (e.g., LSC for &lt;sup&gt;3&lt;/sup&gt;H, GM for other beta emitters, LEG scintillation probe for &lt;sup&gt;125&lt;/sup&gt;I)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Comments:**

<table>
<thead>
<tr>
<th>V. Laboratory Security</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labs locked when unattended</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Refrigerators and walk-in freezers in corridors secured</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Comments:**
<table>
<thead>
<tr>
<th>VI. Personnel Training</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel attended the Radiation Safety Short Course or have previous training and experience</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Personnel appear knowledgeable of radiation safety requirements at time of inspection</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Personnel received instructions/orientation from principal investigator prior to RAM work</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Comments:

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

Comments:

<table>
<thead>
<tr>
<th>VIII. Work Area</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area free of unnecessary clutter</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Radioactive use areas clearly delineated</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Absorbent paper/drip trays in use</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Shielding available</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Comments:

<table>
<thead>
<tr>
<th>IX. Work Procedures</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>No eating, drinking, smoking, application of cosmetics observed and no evidence of same</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Lab coats/gloves and other appropriate personal protective equipment worn</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Film/TLD badges worn and stored properly</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Shielding in use</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Comments:
Recommendations:

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

Audit performed by: ____________________________
Radiation Safety Technologist

Audit reviewed by: _____________________________
Kent Lambert, M.S., CHP
Radiation Safety Officer
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)

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

Beta Emission

<table>
<thead>
<tr>
<th>Maximum Energy</th>
<th>Average Energy</th>
<th>emission per disintegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(MeV)</td>
<td>(MeV)</td>
<td></td>
</tr>
<tr>
<td>0.0186</td>
<td>0.005685</td>
<td>1.000</td>
</tr>
</tbody>
</table>

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

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)

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.9999</td>
<td>0.9999</td>
<td>0.9999</td>
<td>0.9999</td>
<td>0.9999</td>
<td>0.9999</td>
</tr>
<tr>
<td>10</td>
<td>0.9988</td>
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<td>0.9975</td>
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<tr>
<td>30</td>
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<td>0.9963</td>
<td>0.9963</td>
<td>0.9963</td>
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<td>40</td>
<td>0.9952</td>
<td>0.9952</td>
<td>0.9952</td>
<td>0.9952</td>
<td>0.9951</td>
<td>0.9951</td>
<td>0.9951</td>
<td>0.9951</td>
<td>0.9951</td>
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<td>50</td>
<td>0.9940</td>
<td>0.9940</td>
<td>0.9939</td>
<td>0.9939</td>
<td>0.9939</td>
<td>0.9939</td>
<td>0.9939</td>
<td>0.9939</td>
<td>0.9939</td>
<td>0.9939</td>
</tr>
</tbody>
</table>

Beta Emission

<table>
<thead>
<tr>
<th>Maximum Energy (MeV)</th>
<th>Average Energy (MeV)</th>
<th>emission per disintegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15648</td>
<td>0.04947</td>
<td>1.000</td>
</tr>
</tbody>
</table>

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 rad/hr per μCi on 1 cm² 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 ¹⁴C-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 ¹⁴C can be incorporated in the skin and deliver local doses in the order of 10-100 rad per μCi deposited.
Sodium  

**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)

<table>
<thead>
<tr>
<th>Years</th>
<th>Months</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1.0000</td>
<td>0.9780</td>
<td>0.9566</td>
<td>0.9356</td>
<td>0.9150</td>
<td>0.8949</td>
<td>0.8753</td>
<td>0.8561</td>
<td>0.8373</td>
<td>0.8189</td>
<td>0.8009</td>
<td>0.7833</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0.7661</td>
<td>0.7493</td>
<td>0.7329</td>
<td>0.7168</td>
<td>0.6907</td>
<td>0.6706</td>
<td>0.6559</td>
<td>0.6415</td>
<td>0.6274</td>
<td>0.6136</td>
<td>0.6001</td>
<td></td>
</tr>
<tr>
<td>2</td>
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<td>0.5870</td>
<td>0.5741</td>
<td>0.5615</td>
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<td>0.5253</td>
<td>0.5138</td>
<td>0.5025</td>
<td>0.4915</td>
<td>0.4807</td>
<td>0.4701</td>
<td>0.4598</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0.4497</td>
<td>0.4398</td>
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<td>0.4115</td>
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<td>0.3936</td>
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<td>0.3765</td>
<td>0.3683</td>
<td>0.3602</td>
<td>0.3523</td>
</tr>
<tr>
<td>4</td>
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<td>0.3370</td>
<td>0.3296</td>
<td>0.3223</td>
<td>0.3153</td>
<td>0.3083</td>
<td>0.3016</td>
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<td>0.2885</td>
<td>0.2821</td>
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<td>0.2114</td>
<td>0.2068</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>0.2022</td>
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<td>0.1934</td>
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**Positron Emission**

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<th>emission per disintegration</th>
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**Conversion and Auger Electron Emission**

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**Photon Emission**

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<td>1.2745</td>
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**Annual Limit of Intake** (amount resulting in a whole body dose of 5 rem):

- **Ingestion:** 400 µCi
- **Inhalation:** 600 µCi

**Skin Dose:** 6.3 rad/hr per µCi on 1 cm² 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

- LS Window: 0 – 900
- LS Efficiency: 100%

- LS Window: 0 – 900
- LS Efficiency: 100%

- 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 ²²Na 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)

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Beta Emission

<table>
<thead>
<tr>
<th>Maximum Energy (MeV)</th>
<th>Average Energy (MeV)</th>
<th>emission per disintegration</th>
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</thead>
<tbody>
<tr>
<td>1.7104</td>
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<td>1.000</td>
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Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):

- Ingestion: 600 µCi
- Inhalation: 400 µCi

Skin Dose: 7.0 rad/hr per µCi on 1 cm² of skin

The high energy beta from ³²P 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 ³²P, 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 ³²P 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 ³²P.
- Avoid skin exposure by using tools to indirectly handle unshielded sources and potentially contaminated vessels.
Phosphorus

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)

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Beta Emission

<table>
<thead>
<tr>
<th>Maximum Energy</th>
<th>Average Energy</th>
<th>emission per disintegration</th>
</tr>
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<tbody>
<tr>
<td>(MeV)</td>
<td>(MeV)</td>
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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 rad/hr per µCi on 1 cm² 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

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### Beta Emission

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<tr>
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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 rad/hr per µCi on 1 cm² of skin

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

Shielding: No shielding required.

Detection: Liquid scintillation counting.

**LS Window** 0 – 700
**LS efficiency** 97%

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 ³⁵S-methionine or other volatile compounds. Contamination may be found on the inside surfaces and in water reservoirs of incubators used for ³⁵S work, particularly rubber seals.
- ³⁵S may be difficult to distinguish from ¹⁴C because the beta emissions are of similar energy.
Calcium

Ca-45

Atomic Number: 20

Half Life: 162.700 Days

Decay Table

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Beta Emission

<table>
<thead>
<tr>
<th>Maximum Energy (MeV)</th>
<th>Average Energy (MeV)</th>
<th>emission per disintegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2455</td>
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<tr>
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</tbody>
</table>

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 rad hr per µCi on 1 cm² 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

<table>
<thead>
<tr>
<th>Days</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>8</th>
<th>9</th>
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<td>0.2589</td>
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### Conversion and Auger Electron Emission

<table>
<thead>
<tr>
<th>Energy (MeV)</th>
<th>emission per disintegration</th>
<th>Energy (MeV)</th>
<th>emission per disintegration</th>
</tr>
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<tbody>
<tr>
<td>0.00047</td>
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<td>0.06594</td>
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<tr>
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### Photon Emission

<table>
<thead>
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<th>Energy (MeV)</th>
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<tbody>
<tr>
<td>0.00047</td>
<td>1.4468</td>
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<tr>
<td>0.00438</td>
<td>0.66886</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

- **Ingestion:** 40,000 μCi
- **Inhalation:** 20,000 μCi

### Skin Dose:

\[ 0.056 \text{ rad hr}^{-1} \text{ per } \muCi \text{ on } 1 \text{ cm}^2 \text{ of skin} \]

### 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

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<tr>
<th>Years</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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<td>0.7041</td>
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</table>

Beta Emission

<table>
<thead>
<tr>
<th>Maximum Energy (MeV)</th>
<th>Average Energy (MeV)</th>
<th>emission per disintegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.065870</td>
<td>0.017130</td>
<td>1.000</td>
</tr>
</tbody>
</table>

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

- Ingestion: 9,000 µCi
- Inhalation: 800 µCi

Skin Dose: 0 rad/hr per µCi on 1 cm² of skin

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

Detection: Liquid Scintillation Counting

![Graph showing Beta Emission](image)

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

Half Life: 18.660 Days

Decay Table

<table>
<thead>
<tr>
<th>Days</th>
<th>0</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.1620</td>
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<td>0.1345</td>
<td>0.1296</td>
<td>0.1249</td>
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<td>0.1160</td>
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<tr>
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<td>0.0573</td>
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<td>0.0532</td>
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</table>

Beta Emission

<table>
<thead>
<tr>
<th>Maximum Energy (MeV)</th>
<th>Average Energy (MeV)</th>
<th>emission per disintegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.69764</td>
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Photon Emission

<table>
<thead>
<tr>
<th>Energy (MeV)</th>
<th>emission per disintegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0766</td>
<td>0.087795</td>
</tr>
</tbody>
</table>

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

- Ingestion: 500 µCi
- Inhalation: 800 µCi
- Skin Dose: 0 rad/hr per µCi on 1 cm² 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 ³²P.

Special Considerations:
- The high energy beta emissions from ⁸⁶Rb can present a substantial skin and eye exposure hazard.
- The high energy gamma emissions and secondary radiation presents a penetrating external hazard.
- Store ⁸⁶Rb 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

<table>
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<tr>
<th>Hours</th>
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<th>3</th>
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<tr>
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Conversion and Auger Electron Emission

<table>
<thead>
<tr>
<th>Energy (MeV)</th>
<th>emission per disintegration</th>
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<tbody>
<tr>
<td>0.001626</td>
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Photon Emission

<table>
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Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):
- Ingestion: 80,000 μCi
- Inhalation: 200,000 μCi

Skin Dose: 0.9 $\text{rad/hr}$ 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 one's advantage to reduce dose.
Iodine

Half Life: 60.140 Days

Atomic Number: 53

Half Life: 60.140 Days

Decay Table

<table>
<thead>
<tr>
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Conversion and Auger Electron Emission

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Annual Limit of Intake (amount resulting in a whole body dose of 5 rem):
- Ingestion: 40 µCi
- Inhalation: 60 µCi

Skin Dose: 0.07 rad/hr per µCi on 1 cm² 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 Na¹²⁵I solutions at room temperature because freezing results in subsequent volatilization of radiiodine.
- Avoid acidic solutions to minimize volatilization.
- Some radiiodine 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.
Policies and Procedures
For
Radioactive Eye Plaques

Revised October 2012
Contact Information

Radiation Safety Officer

Phone 215-255-7860
Cell 215-651-2211
If no answer: 215-895-2222 Drexel University Public Safety – ask for Radiation Safety

Ocular Oncology Service at Wills Eye Institute

Phone 215-928-3105 or 215-928-3106

Department of Radiation Oncology at Drexel University College of Medicine:

Phone 215-762-8409
After Hours: 215-762-7000 Hahnemann University Hospital – ask for the Radiation Oncologist on-call
1. INDICATIONS FOR RADIOACTIVE EYE PLAQUES

Radioactive eye plaques are used in the treatment of uveal malignant melanomas, retinoblastomas, as well as other assorted intraocular and epibulbar tumors.

2. TYPES OF RADIOACTIVE EYE PLAQUES

Radioactive eye plaques used by Drexel University College of Medicine (DUCOM) contain the isotope Iodine-125. Iodine-125 plaques are assembled at DUCOM and consist of radioactive seeds attached to a gold shell or occasionally to an acrylic or lead shell. A variety of shapes and sizes of gold shells are available. The number of seeds, the activity of the seeds, the shape and size shell, and the geometric configuration of the seeds on the shell are tailored specifically for each patient. The iodine seeds are manufactured, calibrated, and supplied by a commercial vendor.

3. ORDERING/RECEIPT OF RADIOACTIVE SEEDS

Model 6711 radioactive iodine sources or “seeds” are used for radioactive eye plaques. Shipments are received every other week, typically Fridays. The radioactive seeds are packaged in DOT Type A container with a “White I” label. Packages are received by the Radiation Safety Office and surveyed for possible radioactive contamination. The Department of Radiation Oncology staff is contacted once the package is determined to be free of contamination.

After the package is opened by the radiation oncology physicist, the seed vial is swiped and the swipe assayed for possible radioactive contamination. The information on the outer seed container is compared to the shipping invoice/vendor documentation, including date of shipment, lot number, activity per seed and number of seeds shipped. Information listed on the inner seed vial is likewise verified with the outer container information and vendor documentation.

The radiation oncology physicist assays at least 20% (≥10 seeds) of the seeds received. Measured seed activity should be within ±5% of the activity indicated on the vendor issued calibration certificate (corrected for decay). If the difference between the assay and the calibrated activity exceeds ±5%, the lot will not be placed into service. If the difference between the assay and the calibrated activity exceeds ±7%, the lot is rejected and the vendor is contacted.

The number of seeds are counted by the physicist to confirm the number of seeds received match the vendor documentation.

A tag is affixed to the outer seed container and the seed lot number, number of seeds, activity per seed and total activity are recorded by the physicist. Each shipment of seeds and the associated assay are recorded in the inventory log book.
A NIST traceable calibration seed is ordered every two years. It will be used to confirm the calibration of the dose calibrator used to assay seeds used in treatment.

4. ORDERING A RADIOACTIVE EYE PLAQUE

One of the staff physicians at the Oncology Service of Wills Eye Institute will refer patients for radioactive eye plaques to the Department of Radiation Oncology at DUCOM. The physician in the Oncology Service or an employee in the Oncology Service designated by the physician will contact one of the radiation physicists or radiation oncologists at the Department of Radiation Oncology at DUCOM and relay to that individual information derived from examination of the patient in the Oncology Service. This information will include the name, race, age, and sex of the patient, the eye involved, the type of tumor, the tumor’s location relative the optic disc and ora serrata, the dimensions of the tumor, the history of any prior ocular irradiation, and the projected date of surgery for radioactive eye plaque implantation. Patient information may be provided by telefacsimile or other electronic means. From this information, the radiation oncologists and radiation physicists at DUCOM will plan and assemble an appropriate plaque to treat the patient’s tumor.

5. RADIOACTIVE EYE PLACe DOSIMETRY

To assure that the treatment planning software operates properly, the following will be verified initially and after any software revision:
- The source-specific input parameters required by the dose calculation algorithm;
- The accuracy of dose and treatment time calculations at representative points; and
- The accuracy of isodose plots and graphic displays.

This will be accomplished by entering data from a plan run on the previous software version and comparing the output (dose and treatment times, isodose plots, etc.).

A treatment plan will be generated by the radiation physicist or dosimetrist in accordance with the orders of an attending Radiation Oncologist specifically named on the radioactive material license issued to DUCOM (physician authorized user). Each plan is assigned a log number which is listed in the eye plaque copybook, along with the patient specifics.

The therapeutic eye plaque dosimetry calculations will be performed by the physics staff of the Department of Radiation Oncology of DUCOM. The treatment plan will be printed and copies placed in the patient’s Wills Eye Institute record, in the patient’s Oncology Service record, and in the patient’s DUCOM Department of Radiation Oncology record.

The radiation physicist or dosimetrist who performed the eye plaque dosimetry will sign off on the appropriate form.
6. TREATMENT PLAN REVIEW

Once a treatment plan has been generated by the radiation physicist or dosimetrist, the Summary of Dosimetry form will be completed. Information on this form includes:

- Patient name
- Implant date
- Involved eye (left or right)
- Seed lot number
- Number of seeds
- Activity (apparent) per seed
- Total seed (apparent) activity
- Total treatment time
- Plaque identification and description
- Estimated dose to the tumor apex
- Estimated doses to the tumor base (1 mm tissue depth), optic disc and macula
- Dose rates to the tumor apex, tumor base, optic disc and macula
- Muscle offset adjustment (for cases when plaque must be placed over muscle)

A medical physicist not involved with the treatment planning will review both the treatment plan and complete the Summary of Dosimetry. Information received from the Ocular Oncology Service will be compared to that used in the treatment plan, including patient demographics, involved eye, tumor diagnosis, tumor dimensions, and plaque size and specifications requested by the Ocular Oncology Service. Total seed activity based on the treatment plan will be verified. Absorbed doses to the tumor apex and base, the optic disc and macula as determined by the treatment plan will be verified to be as specified by the physician authorized user. The reviewing physicist’s approval of the plan will be indicated by signature on the Summary of Dosimetry.

The physician authorized user likewise must review and approve the treatment plan and its specifics for that patient. Approval is indicated by signing and dating the Summary of Dosimetry form. This form is the written directive as defined in U.S. Nuclear Regulatory Commission regulations (10 CFR 35.2) and specified in 10 CFR 35.40.

The $^{125}$I Eye Plaque Treatment Confirmation form is used in conjunction with the Summary of Dosimetry form to verify the physician’s intent and confirm that the treatment conforms to that prescribed by the physician authorized user. This form is used at several stages of the treatment process: pre-implant, post implant and post explant. Prior to implant, the physician authorized user verifies that the procedure is appropriate for the patient, the physicist confirms that the physician has reviewed the treatment plan and signed the written directive, and the physicist verifies that the sources used agree with the treatment plan.
After the implant, the final prescribed doses and dose rates are indicated as well as the time of implant. The physician authorized user signs this section of the form.

After explant, the physicist (or other trained personnel) records the explant time, and calculates the administered dose to the base and apex of the tumor. This is compared to the prescribed dose to assure that it is within 10%. A physicist indicates the post procedure dose calculations are correct.

The Eye Plaque Treatment Confirmation form also provides a place to note an emergent verbal change to the written directive has taken place and advises revising the written directive within 48 hours as required by regulation.

7. RADIOACTIVE EYE PLAQUE ASSEMBLY

Radioactive eye plaques will be assembled by personnel of the Department of Radiation Oncology of DUCOM in accordance with the treatment plan generated by a physicist or dosimetrist and approved by a Radiation Oncologist.

To confirm that the correct radioactive seeds specified in the treatment plan are actually used, both the inner and outer seed vial containers as well as the outer tag will be examined to verify that the lot number matches the lot number specified by the treatment plan. Seeds are glued onto the shell using a cyanoacrylate based adhesive (e.g., SuperGlue, Krazy Glue) in the geometry specified in the treatment plan.

Assembled eye plaques will be leak tested prior to transportation to Wills Eye Institute and implantation. A cotton swab moistened with water will be brushed over the plaque. Swabs will be assayed by gamma counting or liquid scintillation counting, depending on availability of equipment, to determine if there is any removable contamination. If there is evidence of contamination, the Radiation Safety Officer will be notified immediately.

Plaque characteristics, including size, shape (e.g. round, notched), the number of seeds, and the geometric configuration of the radioactive seeds will be compared to the treatment plan by a physicist that did not assemble the plaque. The physicist will confirm agreement with the treatment plan.

A logbook of seed use is maintained which includes the following information:
Date and time the seeds are removed from inventory and placed on plaque;
Patient’s name;
Authorized user;
Location of use (e.g. Wills Eye Institute, 7th Floor);
Plaque name and identification;
Number of seeds removed from inventory and on plaque;
Activity (apparent) of seeds removed from inventory and on plaque;
Number of seeds in inventory;
Name of individual removing seeds;
Date and time seeds returned to inventory;
Number of seeds returned to inventory;
Number of seeds in inventory after seeds were returned;
Name of individual returning seeds.

8. TRANSPORTATION OF RADIOACTIVE EYE PLAQUES

The radioactive eye plaques will be transported from DUCOM to Wills Eye Institute prior to the time of the scheduled plaque implantation surgery by personnel from DUCOM’s Department of Radiation Oncology. Transportation of eye plaques by vehicle will comply with U.S. Department of Transportation requirements, including shipping papers and Type A packaging.

Radioactive eye plaques and the corresponding acrylic “dummy” shells (used to mark suture locations) are disinfected by soaking overnight in benzyalkonium chloride solution (a mixture of alkylbenzyl dimethylammonium chlorides of the general formula \([C_6H_5CH_2N(CH_3)_2R]Cl\)). Each set (active plaque and associated dummy shell) is placed in a separate well in a lead storage carrier, which is secured in a locked cart overnight.

9. INSTRUCTIONS TO PATIENTS RECEIVING EYE PLAQUES

Prior to implantation of the radioactive eye plaque, personnel from the Oncology Service of Wills Eye Institute will have provided the patient and the patient’s family with written information on radioactive eye plaque therapy, allowable patient activities and restrictions while the plaque is in place, and instructions for returning for eye plaque removal and follow-up exams.

10. RADIATION SAFETY GUIDELINES FOR WILLS EYE INSTITUTE

Radiation exposure is dependent upon the TIME with and DISTANCE from a radioactive source. Personnel will minimize their exposure by limiting the time they spend with a patient containing a radioactive eye plaque and by maintaining distance from the patient (e.g., greater than 6 feet or 2 meters) except for brief intervals required for patient care. Personnel will plan what needs to be done so that their duration of radiation exposure will be minimized.

11. RADIATION SAFETY GUIDELINES FOR PARENTS

A parent of an infant or small child who contains a radioactive eye plaque will be advised to hold the child as little as possible and maintain a distance of 6 or more feet (2 meters) to the extent possible from the child while the child is quiet in his or her crib.
Mothers who are breastfeeding their children should ensure that the child wears the lead covered eye shield at this time.

12. RADIATION SAFETY PRECAUTIONS IN THE OPERATING ROOM

The surgeon and his/her surgical assistant will wear both a whole body film badge and a ring finger monitoring badge for both the plaque implantation and removal procedures.

All other operating room personnel involved in the care of the patient during the implantation or removal procedure will wear a whole body film badge only.

A yellow radiation caution label will be posted on the front of the surgery center chart for each patient with a radioactive eye plaque.

The patient with the eye plaque will be given a yellow radiation caution wrist bracelet in the operating room at the time of the plaque implantation procedure and will wear this bracelet until the plaque has been removed.

13. SURGICAL IMPLANT PROCEDURE

A radiation oncologist and a radiation physicist from DUCOM will be present in the operating room (OR) for the plaque implantation procedure. OR staff perform a “time out” procedure in the operating room to confirm patient identification and the correct eye to be treated (i.e., left, right). At the same time, the radiation physicist and radiation oncologist likewise verify the patient’s identity, the eye to be treated, and the treatment plan (plaque description, number of seeds, total activity, dose to tumor apex and base, and treatment time. The Application of Radioactive Eye Plaque: Radiation Note form is used to document this verification.

The radiation physicist will perform and document a room survey prior to eye plaque implantation to establish background radiation levels.

All procedures of implantation and removal of radioactive eye plaques will be performed by or under the direction of a surgeon from the Oncology Service of Wills Eye Institute.

The radioactive and associated dummy plaques that match the treatment plan for the patient will be removed by the radiation physicist from the disinfecting solution using long-handled forceps or sponge clamps. (Do not handle directly with fingers.) During transport to the operating room table, a strainer is carried underneath for secure transport. The eye plaque and corresponding dummy are placed onto a sterile strainer positioned in a metal bowl. Betadyne solution is poured to cover the plaque and dummy
unless the patient is allergic to iodine in which case sterile water or sterile saline is used.

Before insertion into the eye, the surgeon will rinse the dummy thoroughly in sterile water or balanced saline solution, and place the dummy on the operating instrument table. The surgeon will place the dummy plaque in the treatment location and will use it to mark the suture locations with a sterile marker. The dummy plaque is then removed and sutures secured at the marked locations.

The surgeon removes the radioactive plaque from the strainer and rinses the plaque as described for the dummy. The surgeon reads aloud the number scored on the back of the plaque (the plaque identification number), counts the number of mounted seeds, and ascertains that the seeds are securely mounted on the shell. DUCOM personnel will verify that the plaque is the one that has been assembled for the patient and will account for all the seeds. The treatment will continue only if the radiation oncologist, physicist, and surgeon all agree that the plaque number and seed count are correct for the patient being treated.

The radioactive plaque will be lifted by the surgeon from the operating instrument table with forceps, positioned on the surface of the eye overlying the tumor, and sutured in place.

After dressing (antibiotics, gauze) has been taped over the eye, a lead lined patch will be placed over the bandaged eye and taped in position. The radiation physicist will survey around the patient, across the operating room instrument table, and around the surgery floor area to assure the absence of any misplaced radioactive seeds. The survey will be documented on the appropriate form.

14. POST OPERATIVE RECOVERY

To the extent practicable, patients with radioactive eye plaques will be grouped together in the post-operative recovery area and will have a shielded eye patch over the eye to reduce radiation exposure to other patients and nursing staff while awaiting transport to arranged lodging.

15. SURGICAL EXPLANT PROCEDURE

DUCOM personnel will return to Wills Eye Institute on the date and at the time scheduled for the plaque removal procedure.

The plaque will be removed by the surgeon from the eye with forceps, and placed on the operating room table for a seed count by the surgeon. This count is verified with the radiation physicist or radiation safety personnel. Using forceps, the surgeon places
the explanted plaque into a strainer cup containing endozyme cleaner, being held by
the DUCOM staff member.

DUCOM personnel will then physically count the number of seeds to verify that the
number removed is the same as the number implanted, as indicated by the surgeon.

Following removal of the plaque from the eye by the surgeon and its receipt and
possession by the DUCOM personnel, the patient will remain in the Operating Room
until the personnel from DUCOM have monitored the patient and verified the absence of
any radiation source on the patient. This survey is documented on the appropriate
form.

The actual dose delivered will be determined using the effective treatment time and the
initial hourly dose rate. This will be compared to the Authorized User’s prescribed dose.
If the dose delivered differs from the dose prescribed by more than 10%, the radiation
oncologist and radiation safety officer will be notified.

In the unlikely event that the personnel from DUCOM are delayed beyond the
scheduled time of eye plaque removal, the plaque will be placed inside a protective lead
container (possessed by the Ocular Oncology Service for just this purpose) by the
surgeon from the Ocular Oncology Service. The lead container holding the plaque will
be placed in a secure location until the DUCOM personnel arrive to take possession of
the plaque. The Radiation Safety Officer will be notified whenever such a circumstance
occurs.

16. DEVICES FOR RADIATION SURVEYS AND MONITORING

A calibrated portable radiation survey meter will be maintained in good operating
condition at Wills Eye Institute.

Personal radiation monitoring devices will be provided to Oncology Service staff,
physicians and fellows and to all nursing personnel who routinely care for patients with
implanted radioactive eye plaques.

- Each of these individuals will wear his or her radiation film badge at all times.
- Only the radiation badge assigned to the particular physician or nurse will be worn
  by that individual.
- Film badges will not be taken home.
- A new radiation badge will be given to each worker participating in the care of
  patients having an implanted radioactive eye plaque at the beginning of each wear
  period and the old badges will be collected by DUCOM personnel for processing.
17. RADIATION SAFETY EVENTS

A. DISPLACED RADIOACTIVE SEED OR EYE PLAQUE
If a radioactive eye plaque or a radioactive seed from an eye plaque becomes displaced from its implanted position but remains in the eye, the following steps will be taken:

A surgeon from the Oncology Service will be called immediately to assess the situation and take appropriate action.

- In the event of a loose eye plaque, the only action that will usually need to be taken will be re-suturing the plaque to the sclera. This can be done by the surgeon in the patient’s room under topical or local anesthesia.

- In the event of a displaced seed from the plaque, the surgeon will need to grasp the loose seed with forceps, lift it away from the eye, and deposit it in the lead container. The lead container will then be placed in a secure location. Personnel from the Department of Radiation Oncology and Radiation Safety from DUCOM will be notified and asked to respond.

The Radiation Safety Officer will be notified of this occurrence.

B. BROKEN OR CRUSHED RADIOACTIVE SEED OR EYE PLAQUE
If a radioactive eye plaque or a radioactive seed from an eye plaque becomes not only displaced from the eye but is also damaged (broken, crushed, etc.) such as by being stepped upon, the following steps will be taken:

1. Ventilation of the room in the form of fans or ventilators will be shut off immediately.

2. Damp towels will be dropped on the suspect material.

3. If possible, the room will be evacuated. In any event, all hospital personnel and the patient will remain at least several feet away from the suspect material until the Radiation Safety Officer has surveyed the situation and completed any required cleanup.

4. If the seed or plaque was broken or crushed by being stepped upon, the individual’s shoe(s) will be removed and kept in the room until it (they) has been monitored and verified as uncontaminated, decontaminated or disposed of properly.
5. The Radiation Safety Officer and personnel from the Oncology Service will be called at once by nursing personnel to monitor the situation and initiate any appropriate clean up and decontamination.

C. LOST RADIOACTIVE SOURCE
If radiation exposure monitoring of a patient’s room suggests that a radioactive eye plaque has been lost, the following steps will be taken:
1. Notify the Radiation Safety Officer immediately.

2. Contact the lodging facility where the patient stayed and inform the facility not to clean or remove any materials from the patient’s room until it can be surveyed by Radiation Safety.

3. Contact patient transportation services (e.g., shuttlebus) to sequester the bus until it can be surveyed by Radiation Safety.

D. MEDICAL ALERT ON PATIENT WITH EYE PLAQUE
If a patient having an implanted radioactive eye plaque requires emergency medical care, the following steps will be taken:
1. Required emergency medical care will be provided as if the patient did not have the radioactive eye plaque; however, personnel caring for the patient in this circumstance will be told of the radiation source and advised to stay as far away from the patient’s head and radioactive eye plaque as possible during performance of the required emergency services.

2. Personnel from the Oncology Service will be called as soon as possible to assess the situation and decide if the radioactive eye plaque should be removed during the patient’s emergency treatment. If such an emergency surgical procedure is judged mandatory, the surgeon may remove the radioactive eye plaque at the bedside. In such a circumstance, the removed plaque will be dealt with as indicated previously.

3. If the patient’s medical condition warrants his or her transfer to another department or to another hospital, this transfer will be performed by whatever means are judged most appropriate by the physician in charge of the patient’s emergency care.

4. Once the patient’s medical condition is stabilized, radiation monitoring and precautions as specified above will be resumed.

5. The supervisor will notify the Radiation Safety Officer promptly of any medical emergency.

E. DEATH OF PATIENT CONTAINING RADIOACTIVE EYE PLAQUE
In the event of death of a patient containing a radioactive eye plaque, the following steps will be taken:

1. Personnel from the Oncology Service and the Radiation Safety Officer will be called immediately so that they may remove the radioactive eye plaque before any post mortem care is given to the body, an autopsy is performed, or the body is released to an undertaker.

2. Following removal of the radioactive eye plaque, a survey of the body and the room will be performed as specified previously. In such a circumstance, the removed plaque will be dealt with as previously described.

F. NOTIFICATION OF RADIATION SAFETY OFFICER

In addition to the events specified above, the Radiation Safety Officer will be notified of any occurrence in which there is a question concerning radiation safety.
Forms
Background

Patients are receiving radiation therapy for eye disease. A radioactive implant called an eye plaque has been sutured to the eye. Typically, the implant remains on the eye for 4-5 days, with implants placed on Thursdays and removed on Mondays or Tuesdays.

The eye plaque consists of a metal shell with radioactive sources attached to the concave side. Figure 1 shows an eye plaque and Figure 2 shows the radioactive sources (called seeds because of their shape). The shell can range in size from less than 1/4 inch to about 1 inch in diameter. Sometimes, unusual shaped shells are custom made for patients. As few as 4 or as many as 25 seeds may be used. The radioactive material, iodine-125 (I-125 or 125I), is contained within a titanium capsule (see Figure 3).

Precautions Around Patient

Because the radioactivity is contained within the titanium capsule, it is never released into the body. There is no radioactivity in the patient’s body fluids. As a result, the only precautions are from the radiation, not the radioactivity. Basic radiation safety principles are:

- **Time** – reduce time near patients
- **Distance** – increase distance from patient
- **Shielding** – place radiation absorbing material between radiation source and people

Radiation Monitoring

Nursing staff caring for these patients in the past have been monitored for radiation exposure and have received minimal exposures. Therefore, hospital staff with less contact with these patients would not receive radiation exposures. To demonstrate this, monitoring badges may be issued to key personnel. If issued, the monitoring badges are exchanged quarterly and the old badge is sent out for processing. Drexel University Radiation Safety Office will supply, deliver, collect and evaluate monitoring badges. Badge reading will be made available. The need for monitoring will be reassessed periodically and, if appropriate, monitoring may be discontinued.

Emergency Procedures

**Dislodged source or plaque**: A plaque has never been dislodged from a patient in the 30+ years that this procedure has been performed. On rare occasion, a seed has come loose from the plaque, but it remained in the eye under the plaque and a seed has never been dislodged from the patient’s eye. Patients should avoid activities involving vigorous head motions or jarring of the head. As such, patients are instructed not to leave the hotel except in a medical emergency. In the unlikely event that a radioactive source or the entire eye plaque becomes dislodged:

- Use a spoon, tweezers or other implement to place it in a jar or other container (one with a lid if available). Do not handle the plaque or seed with your fingers. Handle the plaque or seed gently to avoid crushing a seed.
- A lead container may be provided for this purpose. (Lead is an excellent shield for the radiation from I-125.)
- Place the container in a safe, secure location away from people, such as a far corner of the room.

**Medical Emergency**: A patient may have an unexpected medical emergency in which case the patient’s emergent medical condition needs to be addressed without regard to the eye plaque. Inform medical attendants that the patient has an eye plaque. The patient will wear a wrist band for this reason as well.

*For any emergency contact Wills Eye Institute and Radiation Safety immediately and Radiation Oncology when practicable.*

Patient Room Release

As a standard precaution, the patient’s room should not be cleaned and released for other guests until after 1:00 PM. This allows time to account for all seeds. If a seed is missing, the hotel will be contacted immediately and instructed not to clean the room until cleared by the Radiation Safety Officer.

Emergency Phone Numbers

<table>
<thead>
<tr>
<th>Wills Eye Oncology Services</th>
<th>215-928-3105</th>
<th>or</th>
<th>215-928-3106</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation Safety Officer</td>
<td>215-265-7860 (office)</td>
<td>or</td>
<td>215-651-2211 (cell)</td>
</tr>
<tr>
<td>Radiation Oncology Services</td>
<td>215-762-8409</td>
<td>or</td>
<td>215-762-7000 ask for a radiation oncology resident</td>
</tr>
</tbody>
</table>
Wills Eye Institute / Drexel University College of Medicine
Procedure for Releasing Eye Plaque Implant Patients

Measure the dose rate from the patient at one meter with an operable, calibrated survey meter. Determine the highest dose rate at one meter with the lead shield in place.

<table>
<thead>
<tr>
<th>Dose rate less than or equal to 1 millirem/hour</th>
<th>Dose rate greater than 1 millirem/hour</th>
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<tbody>
<tr>
<td>• Place radiation warning wrist band on patient;</td>
<td>• Follow all instructions for dose rates less than 1 millirem/hour; and</td>
</tr>
<tr>
<td>• Provide the patient with written and verbal instructions, including radiation safety precautions, and scheduled return time;</td>
<td>• Contact Radiation Safety 215-255-7860 or 215-651-2211 for additional instructions.</td>
</tr>
<tr>
<td>• Assess the patient’s ability to comprehend and comply with the instructions;</td>
<td></td>
</tr>
<tr>
<td>• Document the patient’s lodging plans and telephone number during treatment;</td>
<td></td>
</tr>
<tr>
<td>• Confirm emergency contact information for the patient;</td>
<td></td>
</tr>
<tr>
<td>• Contact the patient daily. Remind patient to return as scheduled.</td>
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</tbody>
</table>

Release Worksheet and Documentation

Patient’s name: ___________________________ Date: ______________

Maximum dose rate at 1 meter: _____ millirem/hour. Surveyor’s initials: _____

☐ Radiation warning wrist band placed on patient
☐ Discharge instructions and radiation safety precautions explained to patient, family and/or guardian.
☐ Written instructions provided to patient
☐ Return schedule explained and provided in writing to patient.
☐ Patient understands instructions and appears compliant.

Patient will be staying at: ☐ Watermark ☐ Other: ___________________________

If not Watermark, phone number(s) where patient can be reached: ___________________

If not Watermark, confirm patient has reliable means of returning for eye plaque removal. ☐

Describe: ___________________________

Emergency contact in case patient does not return:

Name: ___________________________ Phone: ___________________________ Cell: ___________________________

Signature: ___________________________ (physician or discharge nurse)
# Summary of Dosimetry

For Eye Plaques with I-125 Seeds (Model 6711)

## Patient and Plaque Data

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<thead>
<tr>
<th>Name</th>
<th>Treatment #</th>
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<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Diagnosis</th>
<th>Involved Eye</th>
<th>left / right</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Apparent activity (mCi/seed)</th>
<th>Implant date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total apparent activity (mCi)</th>
<th>Seed Lot #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plaque name</th>
<th>Plaque Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># of Seeds</th>
<th>Additional Description</th>
<th>full / mmposterior</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Point Dose Rates

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>Base</th>
<th>Apex</th>
<th>Estimated dose rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
<td></td>
<td>Optic Disc</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dose Rate (cGy/hr)</th>
<th>Optic Disc</th>
<th>Macula</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Treatment Plan Basis

[cGy] to the tumor base at [1 mm] tissue depth

[cGy] to the tumor apex at [mm] tissue depth

Treatment time [hours] = [days] + [hours]

Estimated dose to optic nerve [cGy]

Estimated dose to macula [cGy]

## Muscle Offset – to be used ONLY if plaque is placed over a muscle

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>Dose Rates (cGy/hr)</th>
<th>Time (hr)</th>
<th>Dose (cGy)</th>
<th>Dose to Apex (cGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Apex        |                       |           |            |                    |

## Prepared by: 

Date

## Reviewed by: 

Date

## Approved by: 

(attending physician) Date
\[125\text{I} \text{ Eye Plaque Treatment Confirmation Form}\]

**Before Implant**
- I have reviewed the case and established that the procedure is appropriate.
  
  Signature: 
  (Physician) 
  Date: 

- I confirmed that the physician has signed the initial prescription or treatment plan which includes dose rate, total dose at a specified location, isodose contour and implant duration. (If not explain.)
  
  Signature: 
  (Physician / Dosimetrist) 
  Date: 

- I have verified that the radioactive sources used are in agreement with the treatment plan.
  
  Signature: 
  (Physician / Dosimetrist / Technologist) 
  Date: 

**After Implant**
Based on the actual implant, the final prescription follows:

- Dose prescribed to the base: cGy to the apex: cGy
  
- Dose rate at the base: cGy/hr at the apex: cGy/hr

- Implant time: hr : min AM PM mm dd yy

  Plaque placed over muscle? 
  Yes No

Signature: 
(Physician) 
Date: 

**After Explant**

- Explant time: hr : min AM PM mm dd yy

  Explant Duration: hr eff. hrs

- Dose administered to base: cGy Dose administered to the apex: cGy

- Dose administered is within 10% of dose prescribed? 
  Yes No

Signature: 
(Physician / Dosimetrist / Technologist) 
Date: 

**Review of Dose Calculations** (by person not performing original calculations)

- I have reviewed the dose calculations and checked for correctness of:
  a. Transfer of requisition data and use of data pertinent to the treatment
  b. Simple arithmetic operations

Signature: 
(Physician) 
Date: 

**Exemption under Emergent Conditions**

- A delay to provide a written revision to the written directive would jeopardize the patient’s health; therefore, an oral revision to the written directive has been made. This will be documented ASAP in the patient’s record and a revised written directive will be signed within 48 hours.

Signature: 
(Physician) 
Date: 
Application of Radioactive Eye Plaque

Radiation Note

Patient Name ___________________________  Date _____________________

Patient is identified _______________

Treatment eye is identified _______________

Seed count is performed by surgeon _________ and verified by physicist _________

At _____________ a ___ mm _____________ eye plaque was inserted in the ___ eye. The plaque contains _________ seeds of I-125, each with an apparent activity of ____________ mCi for a total activity of _________ mCi. The implant is planned to deliver ____________ cGy to the apex of the tumor at a depth of _________ mm and ____________ cGy to the base at a depth of 1.0 mm. The planned duration of the implant is _________ hours and is scheduled for removal on ______________.

Seed distribution on plaque: _______ Full _______ mm posterior

Other ____________________

Full radiation precautions are in effect.

Radiation Oncologist ____________________________
<table>
<thead>
<tr>
<th>Initials</th>
<th>Inventory Seeds</th>
<th>Plague on Time &amp; Date (mcl)</th>
<th>Agar</th>
<th>Plague on Activity on Apparent Date Start</th>
<th>Assay Date (mcl)</th>
<th>Date Received</th>
<th>Certification Number:</th>
<th>Eye Plague Brachytherapy Source Log</th>
</tr>
</thead>
</table>

Seeds placed into storage for disposal by decay. By: ___________________ Date: ________
Radiation Safety Precautions

The eye plaque stitched to your eye contains several small metal rods (called seeds) that are radioactive. Each seed is about 1/3 of an inch long as shown in Figure 1. Figure 2 shows an eye plaque and seeds.

There are 3 ways you can reduce radiation exposure to other people.
1. You can minimize the amount of time near other people.
2. You can keep your distance from other people.
3. You can use shielding to absorb the radiation.

Applying the above guidelines:

- Minimize time spent in close contact with other people. A little time (e.g., to kiss or shake hands) is alright, but keep it brief.
- Try to stay 6 feet or more from other people. For example, have visitors sit across the room or at the foot of the bed.
- The eye patch reduces radiation exposure to everyone around you. You should keep it on as much as possible and especially when you are near (within 6 feet of) other people.

Even though the amount of radiation is low and not likely to have any effects, we recommend avoiding pregnant women and children visitors because they are more sensitive to radiation.

We strongly recommend that you stay at the hotel until your scheduled return (unless, of course, you have a medical emergency).

Be aware that you may not be able to tell how far away things are from you (decreased depth perception), so avoid situations where this might cause problems or injury.

It is not likely, but it is possible that the eye plaque or a radioactive seed can become dislodged. You should avoid activities involving vigorous head motions or jarring of the head. In the unlikely event that a radioactive seed or the entire eye plaque becomes dislodged:

- Use a spoon, tweezers or other implement to place it in a jar or other container (one with a lid if available). Handle the plaque or seed gently so that you do not crush a radioactive seed. Do not handle the plaque or seeds with your fingers.
- Place the container in a safe location away from people, such as a far corner of the room.
- Contact Wills Eye Institute and the Radiation Safety Officer at the telephone numbers given below.

It is important that you return to Wills Eye Institute at the scheduled time to have the eye plaque removed. Not returning as scheduled may result in serious side effects.

Return on ___________________ at ____________
(day of week) (date) (time)

If you have a medical emergency, be sure to inform the person in charge of your care of the eye plaque and the need for its removal. The wrist band that you are wearing is provided for this reason. Contact Wills Eye Oncology service and Radiation Safety as soon as possible.

<table>
<thead>
<tr>
<th>Wills Eye Oncology</th>
<th>Radiation Safety Officer</th>
<th>Radiation Oncology</th>
</tr>
</thead>
<tbody>
<tr>
<td>215-928-3105 or 215-928-3106</td>
<td>215-255-7860 office or 215-651-2211 cell</td>
<td>215-762-8409 or 215-762-7000 ask for on-call resident</td>
</tr>
</tbody>
</table>
Transportation of Radioactive Material by Non-Physician

Instructions: Use this worksheet to ensure compliance with U.S. Department of Transportation, Nuclear Regulatory Commission, and Environmental Protection Agency regulations for transporting radioactive eye plaques to and from the Wills Eye Institute.

To: Drexel University College of Medicine
From: 245 N. 15th Street
Philadelphia, PA 19102

To: Wills Eye Institute
From: 840 Walnut Street
Philadelphia, PA 19107

Mode of Transportation: [ ] Pedestrian [ ] Motor Vehicle

Shipping Date: 

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Act. Activity (mCi)</th>
<th>Physical Form</th>
<th>Description of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-125</td>
<td>× 1.78 =</td>
<td>Sealed source</td>
<td>Seeds in eye plaques</td>
</tr>
</tbody>
</table>

Completed

<table>
<thead>
<tr>
<th>Procedural Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Shipping paper properly completed; package securely closed with packing tape.</td>
</tr>
<tr>
<td>☐ DOT Type A container used.</td>
</tr>
<tr>
<td>☐ Radiation survey readings: ______ mR/h at contact, ______ mR/h at 1 meter. (Dose rates shall be not more than 0.5 mrem/h at contact and less than 0.05 mrem/h at one meter.)</td>
</tr>
<tr>
<td>☐ White I labels on opposing sides of the package; nuclide and total actual activity (MBq) on labels.</td>
</tr>
<tr>
<td>☐ Wiped outside of package (300 cm²) with filter paper or cotton swab and surveyed wipe with crystal scintillation meter in a low background area. Assumed 10% counting efficiency.</td>
</tr>
<tr>
<td>☐ Removable contamination: ______ wipe cpm — ______ background cpm — ______ net cpm</td>
</tr>
<tr>
<td>☐ Confirmed that removable contamination is less than 700 cpm (2200 dpm/100 cm²).</td>
</tr>
<tr>
<td>☐ Package marked: Radioactive Material Type A Package UN2915 USA DOT 7A Type A &quot;RQ&quot; when actual activity exceeds 10 mCi (370 MBq) Name and address of shipper and consignee</td>
</tr>
</tbody>
</table>

Shipping Requirement

☐ Package and contents secured to prevent shifting during normal conditions of transportation.

Shipping Paper

<table>
<thead>
<tr>
<th>Proper Shipping Name</th>
<th>Hazard Class</th>
<th>UN No.</th>
<th>Packing Group</th>
<th>Subsidiary Risk</th>
<th>Radionuclide</th>
<th>Physical/Chemical Form</th>
<th>Activity (MBq)</th>
<th>Label Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ Radioactive material, Type A package</td>
<td>7</td>
<td>2915</td>
<td>none</td>
<td>none</td>
<td>I-125</td>
<td>Solid Sealed Source Encapsulated Iodide</td>
<td></td>
<td>White I</td>
</tr>
</tbody>
</table>

Emergency Response Telephone Number: 215-651-2211
Emergency Response Info on Reverse Side.

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by motor vehicle according to the applicable international and national governmental regulations.

Signature: ____________________________ Date: ____________________________

Printed Name: ____________________________ Title: ____________________________
POTENTIAL HAZARDS

HEALTH
- Radiation presents minimal risk to transport workers, emergency response personnel and the public during transportation accidents. Packaging durability increases as potential hazard of radioactive content increases.
- Undamaged packages are safe. Contents of damaged packages may cause higher external radiation exposure, or both external and internal radiation exposure if contents are released.
- Type A packages (cartons, boxes, drums, articles, etc.) identified as “Type A” by marking on packages or by shipping papers contain non-life endangering amounts. Partial releases might be expected if “Type A” packages are damaged in moderately severe accidents, but risks to people are minor.
- Radioactive White-I labels indicate radiation levels outside single, isolated, undamaged packages are very low (not more than 0.005 mSv/h (0.5 mrem/h)).
- Released radioactive materials or contaminated objects usually will be visible if packaging fails.
- Low radiation hazard when material is inside container. If material is released from package or bulk container, hazard will vary from low to moderate.
- Runoff water from control of cargo fire may cause low-level pollution.

FIRE OR EXPLOSION
- Material does not burn but may become airborne in a fire.
- Radioactivity does not change flammability or other properties of materials.

SOURCE DESCRIPTION SPECIFICS
- Radioactive material is contained inside titanium capsule the size of a short piece of pencil lead. Source must be damaged (crushed, bent, or partially melted) for it to release radioactivity.

PUBLIC SAFETY

First Call Emergency Response Telephone Number. If shipping paper not available or no answer, contact the Pennsylvania Department of Environmental Protection (PADEP) at 484-250-5900.
- Prioritize rescue, life-saving, first aid, fire control, and other actions, higher than the priority for measuring radiation levels.
- PADEP must be notified of accident conditions. PADEP is usually responsible for decisions about radiological consequences and closure of emergencies.
- As an immediate precautionary measure, isolate leak area for at least 10 meters (30 feet) in all directions. Stay upwind. Keep unauthorized personnel away.
- Detain or isolate uninjured persons or equipment suspected to be contaminated; delay decontamination and cleanup until instructions are received from PADEP.

PROTECTIVE CLOTHING
- Positive-pressure self-contained breathing apparatus (SCBA) and structural firefighters’ protective clothing provide adequate protection. Radioactive material is unlikely to become airborne except in a fire.

EVACUATION
- When package is involved in a major fire, consider an initial evacuation distance of 100 meters (300 feet) in all directions. No other evacuation is warranted.

FIRE
- Presence of radioactive material will not influence the fire control processes and should not influence selection of techniques.
- Move containers from fire area if you can do so without risk.
- Do not move damaged packages; move undamaged packages out of fire zone.
- For a small fire, use dry chemical, CO₂ water spray, or regular foam.
- For a large fire, dike fire-control water for later analysis and disposal.

LEAK
- Do not touch damaged packages or leaked material. Prevent spread of contamination by covering leak (e.g., with tarpaulin).

FIRST AID
- Call 911 or Emergency Medical Service.
- Medical problems take priority over radiological concerns. Use first aid treatment according to the nature of the injury. Do not delay care and transport of a seriously injured person.
- Give artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult.
- In case of contact with substance, wipe from skin immediately; flush skin or eyes with running water for at least 20 minutes.
- Injured persons contaminated with released material are not a serious hazard to health care personnel, equipment or facilities.
- Make medical personnel aware of the material involved, so they can protect themselves and prevent spread of contamination.
- Uptake of radioactive iodine by the thyroid can be blocked or reduced by prompt administration of Potassium Iodide USP.
Monoclonal Antibody Treatment

Radiation Safety Procedures
Section 1. Background

The monoclonal antibody Anti-EGFr-425 is labeled with iodine 125 and administered to human research subjects with high grade gliomas in accordance with the research protocol approved by the Drexel University Institutional Review Board.

Section 2. Authorization

From a radiation safety perspective, this is research study is conducted under the authorization of:

Drexel University Institutional Review Board
Drexel University College of Medicine Radiation Safety Committee

The study is conducted under a license issued by the Pennsylvania Department of Environmental Protection to Drexel University College of Medicine.

Section 3. Authorized Users

The authorized user(s) for this study must be specifically listed on the Drexel University College of Medicine radioactive material license.

The authorized user for performing HAMA assays must be approved by the Radiation Safety Committee.

Section 4. Labeling of Monoclonal Antibody

The radiolabeling of the monoclonal antibody shall be performed by a radiopharmacy appropriately licensed to produce and supply radioactive pharmaceuticals. The radiolabeling of monoclonal antibodies shall not be performed at Drexel University College of Medicine.

Section 5. Receipt of Radiolabeled Monoclonal Antibody

The radiopharmacy shall ship the radiolabeled monoclonal antibody to the Radiation Safety Office at the following address:

Drexel University
Radiation Safety Office
New College Building, Room 3209
245 N. 15th Street
Philadelphia, PA 19102

An authorized user or designee shall notify the Radiation Safety Office in advance of expected delivery date and time. This is to assure availability of the Radiation Safety Office staff to accept delivery. Notification by fax (215-762-1608) is the preferred method.
Section 2
Monoclonal Antibody Treatments

 Radiation Safety will perform a package survey and log the receipt. Radiation Safety will deliver the package to the authorized user or designee. Alternatively, Radiation Safety will contact the authorized user or designee that the package can be picked up at the Radiation Safety Office.

 Radiation Safety will not deliver the radioactive material if notified that there is a positive HAMA assay for the human research subject for whom the monoclonal antibody was prepared.

Section 6. Use and Storage Locations

The radiolabeled monoclonal antibody may only be administered to human research subjects in the Department of Radiation Oncology’s Exam Room 2.

The radiolabeled monoclonal antibody may be stored in the Radiation Safety Office (New College Building, Room 3209) or New College Building Room 12133.

Radioactive waste may be stored in the Radioactive Waste Storage facility.

Section 7. Written Directive

A written directive shall be prepared and signed by an authorized user in advance of administration of radiolabeled monoclonal antibody. The written directive shall include the following:

- Name of human research subject
- Radioactive drug
- Activity to be administered, and
- Route of administration.

The activity to be administered may be an activity or a range of acceptable activities. If an activity is indicated on the written directive, a medical event is defined whenever the administered activity differs from the prescribed activity by 20%. If a range of activities is indicated on the written directive, a medical event is defined whenever the administered activity is outside of the range.

A file containing the written directive shall be maintained for review by internal auditors and state and federal regulators.

Section 8. Verification of Dosage

The radiolabeled monoclonal antibody must be received as a unit dose. No adjustments to the dose are permitted.

The activity actually administered will be determined by correcting the activity indicated by the radiopharmacy for radioactive decay. The activity will be further verified by directly measuring the activity in a dose calibrator. If the measured activity differs by more than 5% from the activity indicated by the radiopharmacy (after correcting for decay), the dose shall be rejected.
Section 2  
Monoclonal Antibody Treatments

The activity of the unit dose will be compared to the written directive. If the activity in the unit dose differs from the prescribed dose indicated on the written directive by more than 20% or if the unit dose is outside of the range of doses indicated on the written directive, the discrepancy shall be brought to the attention of the authorized user. The authorized user may revise the written directive or chose to not treat the human research subject.

Section 9. Confirmation of Patient’s Identity

The identity of the patient will be confirmed by verifying the patient’s name on one of the following documents:
- hospital card
- wrist band
- driver’s license
- Social Security Card
- passport

Section 10. Patient Instructions

Subjects must be instructed how to reduce doses to others before being released. Instructions must be in writing. The instruction template must be reviewed and approved by the Radiation Safety Officer.

If a human research subject will be admitted to the hospital instead of being released, notify both the Hahnemann University Hospital Radiation Safety Officer and the Drexel University College of Medicine Radiation Safety Officer.

Section 11. Radiation Safety During MAb Administration

The following radiation safety procedures are to be followed:

a) All individuals involved in the administration shall have received radiation safety training.
b) Individuals involved in the administration must wear radiation monitoring devices supplied by Drexel University College of Medicine. The individual injecting the radioactive material will also wear a finger (ring) dosimeter.
b) A syringe shield shall be used to minimize doses to staff.
c) Plastic backed absorbent paper shall be placed at appropriate locations where drips may occur.
d) The IV line shall be checked prior to administration to assure patency.
e) After administration, a radiation survey of the patient must be performed and the results recorded. This will form the basis for allowing the release of the patient. Patient may be released if the dose rate is less than 1 millirem per hour at 1 meter.
f) A radiation survey of all personnel involved must be performed. If any contamination is found, follow personnel decontamination procedures and contact the Radiation Safety Office immediately.
f) A radiation survey of the room must be performed and the results recorded. Any contamination must be cleaned before the room is released for unrestricted use.
Section 12. Confirmation of Administration

The Radiation Safety Officer will be notified immediately if there are any deviations from the written directive during the administration. These could include:

- wrong patient,
- wrong route of administration (e.g., subcutaneous instead of intravenous injection)
- delivering more or less radioactivity than prescribed (e.g., IV line leaks during administration), or
- delivering the wrong drug.

Section 13. Waste Disposal

All radioactive sharps must be put in a sharps container labeled with a caution radioactive material sign.
All contaminated tubing, gloves, absorbent gauze, pads, unused drug, etc. must be placed in a heavy polyethylene bag and the waste turned over to Radiation Safety for disposal at the end of the treatment day. The bagged waste must be tagged with the contents and labeled with a caution radioactive material sign. The exam room shall remain posted with a caution radioactive material sign until the waste has been removed and the room is free of contamination.

If $^{125}$I labeled MAb are to be returned to the supplier, the Radiation Safety Office must be notified in advance to assure all U.S. Department of Transportation / International Air Transport Association shipping requirements are met.

Section 14. Documentation

The following documentation should be kept in a separate file for inspection by the PADEP:

- Package receipt (we provide a copy with the package delivery)
- Written directive
- Administration of radioactive material which includes
  - the radiopharmaceutical
  - patient's name or identification number
  - prescribed dosage
  - determined dosage (decay corrected / measured)
  - date and time of determined dosage
  - name of individual who determined the dosage.
- Patient survey
- Room survey
### Monoclonal Antibody Quality Control Form

#### Patient’s Name

<table>
<thead>
<tr>
<th>Planned treatment date</th>
</tr>
</thead>
</table>

#### HAMA Result

<table>
<thead>
<tr>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
</table>

#### Written Directive

<table>
<thead>
<tr>
<th>Radioisotope</th>
<th>Intended dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{125}$I</td>
<td>mCi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drug</th>
<th>Route of administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAb-425</td>
<td>Intravenous</td>
</tr>
</tbody>
</table>

#### Physician’s Signature

<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
</table>

#### Patient’s identity verified by:

- [ ] insurance card
- [ ] passport
- [ ] Social Security card
- [ ] non-driver’s ID
- [ ] driver’s license
- [ ] other: _______________________

#### Vital Signs

- Blood pressure: ____________ mmHg
- Pulse: ____________ b/m
- SpO$_2$: ____________%
- Temp.: ____________°F

#### After administration

- Dosage administered: ____________ mCi
- Determined by:
  - [ ] decay corrected (if necessary) of vendor calibration
  - [ ] dose calibrator measurement
- Individual determining dose administered: _______________________
- Treatment time and date: ____________ hh : ____________ mm / ____________ mm / ____________ dd / ____________ yyyy

#### After Treatment Vital Signs

<table>
<thead>
<tr>
<th>Blood pressure</th>
<th>Pulse</th>
<th>SpO$_2$</th>
<th>Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>____________ mmHg</td>
<td>____________ b/m</td>
<td>____________ %</td>
<td>____________°F</td>
</tr>
</tbody>
</table>

#### Physician Review

- Was the actual treatment in accordance with the written directive
  - [ ] Yes
  - [ ] No
- Was there any unintended deviation from the written directive
  - [ ] Yes
  - [ ] No

#### Physician’s Signature

<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
</table>
### Monoclonal Antibody Therapy Survey Form

**Section 2**

**Monoclonal Antibody Treatments**

**125I Monoclonal Antibody Therapy Survey Form**

<table>
<thead>
<tr>
<th>Patient Name:</th>
<th>Examin Room #</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last</td>
<td>First</td>
<td>MI</td>
</tr>
</tbody>
</table>

**Authorized User:**

- Radionuclide: **125I**
- Pharmaceutical: **Monoclonal Antibody 425**

---

**Patient Survey**

<table>
<thead>
<tr>
<th>Dose Rate at 1 meter (3 feet):</th>
<th>millirem/hour</th>
<th>Surveyor’s Initials</th>
</tr>
</thead>
</table>

---

**Patient Release and Instructions**

- **☑** Patient may be released from confinement. (Dose rate must be below 2.5 mr/h at 1 meter.)
- **☐** Dose rate exceeds 2.5 mr/h. Patient may **not** be released until patient specific calculations are performed, documented, and approved by the RSO.
- **☐** Patient/guardian given written and verbal instructions to keep radiation exposures to others as low as reasonably achievable.

**Is patient breastfeeding an infant or child?**

- **☐** yes
- **☐** no.
- **☐** If yes, patient given written and verbal instructions to discontinue breastfeeding.

**Instructions provided by:**

- **print name**
- **Initials:**

---

**Room Survey**

- Room (floor, exam table, countertops, instrument stands, etc.) surveyed for contamination with survey meter. If contamination is found:
  - Decontaminate area.
  - Check for removable contamination by wipe test.
  - Dispose of contaminated cleaning materials as radioactive.

**IV lines, saline bag, injection port, gauze and other biohazardous waste surveyed with survey meter**

- **☐** Contamination found.
- **☐** Room decontaminated.
- **☐** Wipe test results attached.
- **☐** Contaminated materials disposed as radioactive.
- **☐** No contamination found.
- **☐** Contamination found.
- **☐** Materials disposed as radioactive.
- **☐** No contamination found.
- **☐** Material disposed as biohazardous.

**Survey meter mfr. and model #**

**Survey meter serial #**

**Surveyor’s notes**

---

**Surveyor**

- **print name**
- **Initials:**
- **Date**

---

**Form instructions:** Retain a copy in the patient’s chart, file a copy in the patient release file, and send a copy to Radiation Safety.

**Rev 1 February 2011**
Appendix 2
Decontamination Procedures

Spill of Radioactive Materials

The following steps should be taken:

- Inform ALL individuals in immediate area of spill, the authorized user and the Radiation Safety Office.
- Contain the spill:
  - Contain the spread of radioactive material
  - Prevent further spread of contamination.
  - Place absorbent pad over affected areas to soak up liquid.
  - Close doors to prevent airborne spread of contamination
  - Limit access of other individuals to area.
  - Turn off fans and air conditioners wherever possible if the possibility of airborne radioactivity exists.
- Survey and decontaminate personnel:
  - Monitor individuals in area to determine degree of personal contamination.
  - Do not permit anyone to leave the area until a survey has been performed.
  - Remove contaminated articles of clothing and place these in a plastic bag for storage.
  - Flush contaminated skin with warm water, followed, if necessary, with warm water and soap.
  - Take special care around open wounds, eyes, nose, and mouth to prevent uptake of radioactive material.
- Measure radiation levels around spill to determine extent of contamination.
- Survey for removable contamination by taking wipe samples and assaying.
- Using either a decontaminating agent or standard cleaning agents and water, place absorbent pads over the affected area cleaning from outside to the inside of the spill to contain the contamination. A fresh pad should be used for each pass over the affected area.
- After preliminary clean up, take survey meter readings at approximately 2" height above surface contamination and perform a wipe test on the affected areas-
- Continue decontamination procedures until following limits are achieved:
  - Radiation levels 0.05 mR/hour 60 cm above floor or 30 cm from work area
  - removable contamination 1000 dpm/100 cm²
- Place all wipes, pads and contaminated articles in plastic bags for either decay in storage or radioactive waste disposal.
- All survey and swipe data to be maintained for final report by the Radiation Safety Officer.
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### REVISION HISTORY

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>11/12/2008</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>10/08/2011</td>
<td>Formatting, Addition of procedures on radiopharmaceutical administration, receipt of packages.</td>
</tr>
<tr>
<td>2</td>
<td>05/09/2012</td>
<td>Corrected fetal dose table. Added tetrofosmin.</td>
</tr>
</tbody>
</table>
GUIDELINES FOR THE SAFE USE OF RADIOPHARMACEUTICALS

- Wear laboratory coats or other protective clothing while in areas where radioactive materials are used.
- Wear disposable gloves at all times while handling radioactive materials.
- Periodically throughout the workday, and before leaving the area at the end of the day, monitor your hands for contamination in a low-background area with an appropriate detection instrument.
- Use syringe shields for routine preparation of multi-dose vials and administration of radiopharmaceuticals to patients, except in those circumstances in which their use is contraindicated (e.g., recessed veins, infants). In these exceptional cases, consider the use of other protective methods such as remote delivery of the dose (e.g., through use of a butterfly valve).
- Do not eat, drink, smoke, or apply cosmetics in any area where radioactive material is stored or used.
- Do not store food, drink, or personal effects in areas where radioactive material is stored or used.
- Wear personal monitoring devices at all times while in areas where radioactive material is stored or used. These devices should be worn as prescribed by the Radiation Safety Officer. When not being worn to monitor occupational exposures, personal monitoring devices should be stored in the work place in a designated low-background area.
- Wear a finger exposure monitor during the elution of generators; during the preparation, assay, and injection of radiopharmaceuticals; and when holding patients during procedures.
- Dispose of radioactive waste only in designated, labeled, and properly shielded receptacles.
- Never pipette by mouth.
- Wipe-test byproduct material storage, preparation, and administration areas weekly for contamination. If necessary, decontaminate or secure the area for decay.
- With a radiation detection survey meter, survey the generator storage, kit preparation, and injection areas daily for contamination. If necessary, decontaminate or secure the area for decay as appropriate.
- Confine radioactive solutions in shielded containers that are clearly labeled.
- Radiopharmaceutical multidose diagnostic vials and therapy vials should be labeled with the isotope, the name of the compound, and the date and time of receipt or preparation. A log book should be used to record the preceding information and total prepared activity, specific activity as mCi/cc at a specified time, total volume prepared, total volume remaining, the measured activity of each patient dosage, and any other appropriate information. Syringes and unit dosages should be labeled with the radiopharmaceutical name or abbreviation, type of study, or the patient’s name.
- Assay each patient dosage in the dose calibrator before administering it. Do not use a dosage if it is more than 10 percent off from the prescribed dosage. When measuring the dosage, you need not consider the radioactivity that adheres to the syringe wall or remains in the needle. Check the patient’s name and identification number and the prescribed radionuclide, chemical form, and dosage before administering.
- Always keep flood sources, syringes, waste, and other radioactive material in shielded containers.
- Because even sources with small amounts of radioactivity exhibit a high dose rate on contact, you should use a cart or other transportation method to move flood sources, waste, and other radioactive material.
SPILL PROCEDURES

MINOR SPILLS OF LIQUIDS AND SOLIDS

- Notify persons in the area that a spill has occurred.
- Prevent the spread of contamination by covering the spill with absorbent paper.
- Clean up the spill using disposable gloves and absorbent paper. Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Also put contaminated gloves and any other contaminated disposable material in the bag.
- Survey the area with a low-range radiation detector survey meter. Check the area around the spill. Also check your hands, clothing, and shoes for contamination.
- Report the incident to the Radiation Safety Office.

Radiation Safety will follow up on the cleanup of the spill and will ensure that the radioactive spill report is completed. Depending on the circumstances Radiation Safety may conduct an independent radioactive spill contamination survey.

MAJOR SPILLS OF LIQUIDS AND SOLIDS

- Clear the area. Notify all persons not involved in the spill to vacate the room.
- Prevent the spread of contamination by covering the spill with absorbent paper, but do not attempt to clean it up. To prevent the spread of contamination, limit the movement of all personnel who may be contaminated.
- Shield the source if possible. This should be done only if it can be done without further contamination or a significant increase in radiation exposure.
- Close the room and lock or otherwise secure the area to prevent entry.
- Notify the Radiation Safety Office immediately.
- Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and then washing with mild soap. If contamination remains, induce perspiration by covering the area with plastic. Then wash the affected area again to remove any contamination that was released by the perspiration.

The Radiation Safety Office will supervise the cleanup of the spill and will assist in completing the radioactive spill report and the radioactive spill contamination survey.

MAJOR AND MINOR SPILLS

The decision to implement a major spill procedure instead of a minor spill procedure depends on many incident-specific variables such as the number of individuals affected, other hazards present, likelihood of spread of contamination, and types of surfaces contaminated as well as the radiotoxicity of the spilled material. For some spills of short-lived radionuclides the best spill procedure may be restricted access pending complete decay.
SEALED SOURCE INVENTORY AND LEAK TESTS

The Radiation Safety Office will maintain an inventory of all sealed sources. The following information will be documented:

- Manufacturer
- Model Number
- Serial Number
- Reference activity and reference date
- Current activity and date
- Source location
- Name of person of conducting physical inventory and date performed

For sources contained in devices, the following additional information will be maintained in the inventory:

- Device manufacturer
- Device model name and model number
- Device serial number

The Radiation Safety Office will conduct a physical inventory of all sealed sources once every calendar quarter. The person conducting the inventory must physically observe the presence of each source. A record of the results of the physical inventory will be maintained by the Radiation Safety Office and a summary of the results will be presented to the Radiation Safety Committee.

The Radiation Safety Office will test the integrity of source containment (leak test) of all sealed beta and/or gamma emitting sources over 0.1 millicuries (3.7 MBq) every 6 months. A source is considered leaking if the test reveals the presence of greater than 5 nC (185 Bq). Leaking sealed sources will be removed from service, contained to prevent the spread of contamination, and disposed or sent out for repair.

The Radiation Safety Officer will be promptly notified if a source is missing, if a source is discovered for which there is no record, or if a source is leaking (> , 185 Bq). The Radiation Safety Officer will prepare any required reports or notifications to regulatory agencies.
DOSE CALIBRATOR QUALITY ASSURANCE

The requirements for quality assurance on equipment used to assay dosages are specified by a nationally recognized standard (e.g., AAPM or NCRP) or in accordance with the manufacturer’s instructions. The latter is preferred although, although it is specific to the instrument manufacturer.

BASED ON NCRP REPORT 99, QUALITY ASSURANCE FOR DIAGNOSTIC IMAGING EQUIPMENT

Before First Use Or After Repair

- Zero Setting
- Test Voltage Setting
- Background Test
- Geometry – LIMIT 2% (generate correction factors for use with the different vial and syringe configurations that will be used)
- Accuracy – span range of energies used (typically $^{57}$Co and $^{137}$Cs vial standards)
- Linearity – use decay vs time method
- Channel Check
- Calcheck Sleeve (or other attenuator system) calibration factors (if applicable)

Daily

- Zero setting test
- Voltage setting test
- Background test
- Constancy Test – LIMIT = 5% (repair)
  - use Cs-137 or other long lived isotope (compare against decay chart or computer generated data)

Quarterly

- Channel Check – LIMIT = 5%
  - use Cs-137 or other long lived isotope (compare against channel decay chart or computer generated data)
- Linearity Test – LIMIT = 5% (repair or correction factor)
  - Use decay vs time OR sleeves

Annually

- Accuracy – LIMIT = 5% (repair)
DOSE CALIBRATOR QUALITY ASSURANCE

**BASED ON MANUFACTURER’S INSTRUCTIONS (CAPINTEC)**

### Daily:

**Auto Zero** - This test will measure the amount of voltage drift that has occurred. If it is out of the expected range, a message will appear stating that it is out of range.

**Background** - This test will measure the background in the lab. If the background is greater than 27uCi and less than 500 uCi the word ‘HIGH’ will appear on the screen. If the background is in an acceptable range, 'OK' will be displayed on the screen. A high reading can be accepted; however, it should be investigated and resolved. If the value is greater than 500 uCi then a message will appear stating that the background is too high.

**System/Voltage Test** - This test will measure the chamber voltage which is set at the factory. If the voltage is out of range a message will alert the user that the System Test failed.

**Data Check** - This test checks to see that the built in nuclide data is OK.

**Constancy** - Accuracy as used for the daily test will require the user to place each of the calibrated sources that have been designated for daily testing in the chamber per the on-screen instructions. Readout provides the user with the deviation as measured. If this deviation is greater than 20% the deviation value will be replaced with dashes-----. If this occurs, identify the reason for the high deviation, or contact Capintec's Service Center.

### Quarterly test – (e.g. every three months):

**System Test or Diagnostics**: This is an internal test of the electronic components in the CRC-dose calibrator. A pass/fail report is issued at the completion of the test.

**Accuracy**: This is a measure of the chambers ability to accurately reflect the activity of a NIST traceable source of radioactive material. It is recommended that this procedure be performed using several calibrated sources over a wide range of energies. This should be tailored to the user’s facility so that the accuracy test is performed on nuclides that are used in the laboratory. (Note: If the constancy is performed with the same sources, then this test is, in effect, performed daily.)

**Linearity**: This is a measure of the dose calibrator’s ability to measure a known radioactive source over several scales in the system. This is most often performed with Technetium using a sleeve method. Decay method can be used for nuclides that are not suitable for the sleeve method or the user can use the proportional method for longer lived nuclides. The range for the linearity test should cover the range of activity used in the laboratory.
Upon installation or as needed:

**Geometry:** This test will assess the response of the chamber to the types of vials and syringes used in radiopharmaceutical processing. Changing the radionuclide sample volume or configuration can significantly affect the measurement of the sample’s activity. This procedure is critical if the user plans to measure beta-emitting nuclides in the chamber as they will be affected by both the container as well as the volume. The user must establish additional parameters to address geometric calibration testing required when syringe or vial changes are made in the department.

**WELL TEST:**

**Daily:**

**Background:** This test should be performed daily and more frequently if the room background changes. Once the background has completed counting, it must be saved by selecting Enter or Well. Background limitation is established by placing a value in the background limitation level established when the instrument was initialized. Enter or Well must be depressed to save the background count.

**Test:** Test of calibration is performed daily. This test is performed with the source used for Auto Calibration. If there is a deviation greater than a factor of 2 an error message will be displayed. The Energy Deviation should fall within 3%. If the Energy Deviation is greater than 5%, an error message will be displayed.

**Weekly:**

**Auto Calibration:** This test sets the high voltage so there is a correct relationship between high voltage, energy and channel. This test should be performed if the Well counter test fails. Auto Cal attempts to bring the energy calibration within 2.0%. If this fails, manual calibration must be performed.

**Quarterly – (e.g. every three months):**

**System Test or Diagnostics:** This is an internal test of the electronic components in the CRC-15. A report is issued at the completion of this testing which indicates if the system has passed or failed.
PATIENT IDENTIFICATION

Prior to administering any radiopharmaceutical, the identity of a patient (or human research subject) will be positively verified. Examples of positive patient identity verification include examining the patient’s:

1. ID bracelet,
2. Hospital ID card,
3. Driver’s license,
4. Social Security card or
5. Other government issued photographic identification (e.g., passport,

Asking or calling the patient’s name does not constitute positive patient identity verification.

If the patient cannot be positively identified, the procedure will be postponed until positive identification can occur.
RADIOPHARMACEUTICAL ADMINISTRATION PROCEDURES

1. Confirm the patient identity as per patient identification policy.
2. Confirm that the patient is not pregnant or breast-feeding as per policy.
3. Provide informed consent and have patient sign form for appropriate nuclear cardiology imaging procedures.
4. Verify the identity, dose and route of administration of the radiopharmaceutical with the prescribed dose from the protocol or standing orders in the procedure manual.
5. In the case of a pediatric patient, the RSO, physicist and/or radiopharmacy will verify appropriate dose based on weight.
6. All doses will be verified in the dose calibrator to be within 20% of the prescribed dose. The technologist will verify by the label on the dose, the identity, dose and route of administration of the radiopharmaceutical and expiration time/date. No dose will be used past its expiration time.
7. All administrations will be performed in designated areas.
8. All injections are performed using radiation safety precautions (i.e., appropriate syringe shields, etc.). All injections are performed using universal precautions (i.e., gloves and lab coats) and aseptic technique.
9. The amount assayed in the dose calibrator will be recorded along with the patient name, identity of radiopharmaceutical, route of administration, time and date injection, site of administration and initials of the person administering. This information will be kept in the binder labeled drug log.
PATIENT RELEASE CRITERIA

PATIENT INSTRUCTIONS

Patients that have received radiopharmaceuticals must receive written instructions to minimize the dose to members of the public prior to releasing the patient, if a member of the public is likely to receive a dose that exceeds 100 millirem. Provide instructions on how to maintain doses to other individuals as low as reasonably achievable to any patient administered an activity greater than listed in the table below. (This is an abridged list; contact the Radiation Safety Officer for other isotopes.)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Activity at or Above Which Instructions are Required (mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc-99m</td>
<td>150</td>
</tr>
<tr>
<td>Tl-201</td>
<td>85</td>
</tr>
</tbody>
</table>

Since these activities are well above clinically administered amounts, no formal instructions are required.

PATIENT RELEASE

Patients that have been administered radiopharmaceuticals may be released provided that the dose to any other member of the public is not likely to exceed 500 millirem. Any patient administered an activity less than listed in the table below may be released. (This is an abridged list; contact the Radiation Safety Officer for other isotopes.)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Activity Below Which Patient May be Released (mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc-99m</td>
<td>760</td>
</tr>
<tr>
<td>Tl-201</td>
<td>430</td>
</tr>
</tbody>
</table>

Since these activities are well above clinically administered amounts in nuclear cardiology, patients may be released.
PREGNANT PATIENTS

If a diagnostic radiation study is medically indicated, the risk to the mother and fetus from not performing the study may be greater than the risk from the radiation associated with the procedure. If the study is justified and is performed, the administered activity should be as low as possible while still providing the required diagnostic information.

The following are employed to determine whether the patient is pregnant.

1. Signs that state: “If you are pregnant or breast feeding, please notify the technologist.” will be prominently posted.

2. The technologist must ask all female patients of reproductive age (12 -55 years) if they are or may be pregnant and if they are breast feeding an infant/child. Use particular discretion to ascertain the possibility of pregnancy in an adolescent.

3. Consider a patient pregnant if:
   a) She indicates that she is or could be pregnant,
   b) She is of reproductive age with a menstrual cycle that is overdue or missed,
   c) Her last menstrual period began more than 10 days ago, she is sexually active and not using a reliable birth control method.

If a patient is considered pregnant, notify the Authorized User. The Authorized User should assess the potential dose and determine whether to proceed with the study. (Use Table 3 to estimate the dose; contact the RSO for assistance if needed.) If the physician feels that it is in the best interest of the patient to proceed, then communicate the risks to the expectant mother in a way that she can make an informed decision.

Table 3

<table>
<thead>
<tr>
<th>Radiopharmaceutical</th>
<th>Administered Activity (mCi)</th>
<th>Early 3 Month 6 Month 9 Month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>rad/mCi</td>
<td>millirad rad/mCi millirad rad/mCi millirad</td>
</tr>
<tr>
<td>Tc-99m MIBI-rest</td>
<td>10</td>
<td>0.056 0.044 0.031</td>
</tr>
<tr>
<td>Tc-99m MIBI-stress</td>
<td>30</td>
<td>0.044 0.035 0.026</td>
</tr>
<tr>
<td>Tc-99m Pertechnetate</td>
<td>20</td>
<td>0.041 0.081 0.052</td>
</tr>
<tr>
<td>Tc-99m PYP</td>
<td>20</td>
<td>0.022 0.024 0.013</td>
</tr>
<tr>
<td>Tc-99m RBC- in vivo</td>
<td>25</td>
<td>0.025 0.017 0.013</td>
</tr>
<tr>
<td>Tc-99m Tetrofosmin</td>
<td>30</td>
<td>0.036 0.026 0.020</td>
</tr>
<tr>
<td>T1-201 Chloride</td>
<td>3</td>
<td>0.359 0.215 0.174</td>
</tr>
</tbody>
</table>

Following an unintended exposure of a woman who later reports that she is pregnant:

1. Prescribe appropriate dose-reduction techniques, e.g. hydration and frequent voiding;

2. Determine whether other nuclear medicine and radiological procedures were performed during the pregnancy and obtain estimates of the radiation dose to the embryo/fetus for all radiological procedure; and

3. Inform the patient and referring physician and provide counseling based on the estimated dose, in conjunction with the referring doctor or the patient’s obstetrician. Termination of pregnancy should not be recommended on the basis of radiation dose for doses less than 10 rad (100 mGy). Nuclear cardiology studies do not result in doses at this level.
**LACTATING PATIENTS**

Certain radiopharmaceuticals can be present in breast milk; therefore, women who are breastfeeding an infant or child require special consideration. A patient who is breast-feeding a child should be advised of the risks of continued breast-feeding before a nuclear cardiology procedure. The risks include both an increased radiation dose to the breasts of the patient and a radiation dose to the child.

If the patient is breast-feeding, the child will receive an internal dose from ingested breast milk in addition to an external dose from close contact with the patient. Advice about the possible need to restrict breast-feeding needs to be given to the patient; this advice will depend on the radiopharmaceutical and its activity, and should ensure that the infant will receive a total effective dose of no more than 100 millirem (1 mSv).

The interruption schedule is provided in Table 4. A brochure in the appendix of this guide provides advice to the breast feeding mother.

<table>
<thead>
<tr>
<th>Radiopharmaceutical</th>
<th>Activity administered to mother</th>
<th>Advice to patient concerning close contact with child</th>
<th>Advice to patient concerning breastfeeding</th>
<th>Documentation of providing instructions to mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc-99m tetrofosmin (Myoview)</td>
<td>10 mCi rest + 30 mCi stress</td>
<td>Restrict contact for 4 hours.</td>
<td>4 hour interruption</td>
<td>Not required</td>
</tr>
<tr>
<td>Tc-99m sestamibi (Cardiolite, MIBI)</td>
<td>10 mCi rest + 30 mCi stress</td>
<td>Restrict contact for 4 hours.</td>
<td>4 hour interruption</td>
<td>Not required</td>
</tr>
<tr>
<td>Tc-99m RBC in vivo</td>
<td>10 mCi</td>
<td>Restrict contact for 2 hours</td>
<td>No interruption. 6 hour interruption</td>
<td>If &gt;50 mCi administered</td>
</tr>
<tr>
<td></td>
<td>20 mCi</td>
<td></td>
<td>9 hour interruption</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 mCi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tc-99m PYP</td>
<td>20 mCi</td>
<td>No restriction</td>
<td>2 hour interruption</td>
<td>Not required</td>
</tr>
<tr>
<td>Tc-99m pertechnetate</td>
<td>20 mCi</td>
<td>No restriction</td>
<td>24 hour interruption</td>
<td>If &gt; 15 mCi administered</td>
</tr>
<tr>
<td>TI-201 Chloride</td>
<td>1 mCi</td>
<td>No restriction</td>
<td>No restriction 14 days</td>
<td>If &gt; 5 mCi administered</td>
</tr>
<tr>
<td></td>
<td>3 mCi</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When interruption of breast-feeding is necessary it may be possible to pump milk prior to the procedure and to store one or more feedings in a refrigerator or freezer. The child should be fed naturally prior to administration of the radiopharmaceutical dose. During the period of interruption recommended above, the mother should regularly express and discard her milk. Following the above interruption schedule will result in doses less than 100 millirem, which is 1/5 of the dose limit designed to protect pregnant workers.
WASTE DISPOSAL

PROCEDURE FOR DISPOSAL OF LIQUIDS

Liquid radioactive waste may be disposed of by release to the sanitary sewer. There are, however other federal, state and local regulations regarding toxic or hazardous properties of these materials with which the institution must also comply. Regulations for disposal in the sanitary sewer appear in 10 CFR 20.2003. Excreta from patients undergoing medical diagnosis or therapy are exempt from the sewer disposal regulations. Nuclear medicine / cardiology procedures do not normally produce liquid radioactive waste for sewer disposal. Contact the Radiation Safety Officer if it becomes necessary to do so.

PROCEDURE FOR DISPOSAL BY DECAY-IN-STORAGE

Short-lived material (physical half-life less than 120 days) may be disposed of by decay in storage. If you use this procedure, keep material separated according to half-life.

- Separate wastes according to half-life and waste stream, e.g. sharps versus other biomedical waste.
- Deface or remove all radioactive labels, symbols and markings from containers and packages prior to disposal.
- When the container is full, seal it, and attach an identification tag that includes the date sealed, the longest-lived radioisotope in the container, and the initials of the person sealing the container. The container may then be transferred to the DIS area.
- Decay the material for approximately 10 half-lives, or until no radiation levels above background are detected at the surface of the waste container.
- Prior to disposal, monitor each container as follows:
  a. Check your radiation detection survey meter for proper operation;
  b. Remove any shielding from around the waste container;
  c. Monitor all surfaces of each waste container in an area with low radiation levels;
  e. Only discard waste that cannot be distinguished from background as a result of the survey. Record the date of disposal, instrument used to make the survey, the background radiation level, the maximum radiation level at the surface of the container, and the name of the individual completing the survey. Do a final check to be sure no radiation labels were missed and are visible prior to disposal.
  f. Containers that can be distinguished from background radiation levels must be returned to the storage area for further decay or disposed of as radioactive waste.

PROCEDURE FOR TRANSFER OF RADIOACTIVE WASTES

Long-lived radioactive materials (half lives >120 days) will need to be disposed of as radioactive and given to a radioactive waste broker for disposal. The Radiation Safety Office will assist with the disposal of radioactive waste through a licensed broker.

PROCEDURE FOR RETURNING RADIOACTIVE MATERIALS TO THE MANUFACTURER

There will be times that radioactive materials will need to be returned to the vendor, such as the return of unused dosages of radiopharmaceuticals instead of storing them as decay in storage waste and the return of...
sealed sources (flood or vial sources). The individual preparing any radioactive packages for shipment must be trained in proper HAZMAT shipping procedures within the past 3 years. (If there is any possibility that the material will be transported by air, then training must occur within a 2 year period.) The individual is responsible for properly assembling the package, ensuring that proper markings and labels are on the package, ensuring that contamination and exposure limits for the package are not exceeded. Following vendor supplied instructions should assure compliance. If there is any doubt, contact the Radiation Safety Office for assistance. All shipping papers need to be kept on file for 2 years.
RADIOLOGICAL SURVEYS

AMBIENT DOSE RATE SURVEYS

Survey Areas

- In radiopharmaceutical elution, preparation, and administration areas, survey at the end of each day of use with a calibrated radiation detection survey meter. Daily surveys are not required in in-patient radiopharmaceutical therapy rooms.

- In radiopharmaceutical storage and radiopharmaceutical waste storage areas, survey weekly with a calibrated radiation detection survey meter.

- In sealed source storage areas, survey quarterly with a calibrated radiation detection survey meter.

Immediately notify the RSO if you find unexpected levels.

REMOVABLE CONTAMINATION SURVEYS

Survey Areas

- In radiopharmaceutical elution, preparation, and administration areas, survey weekly for removable contamination.

- In radiopharmaceutical storage and radiopharmaceutical waste storage areas, survey weekly for removable contamination.

The wipe sample assay procedure should be sufficiently sensitive to detect the presence of 2000 dpm/100 cm² of removable contamination. You must use a radioactive source with a known amount of activity to determine efficiency of the detection system so the wipe sample measurements (usually in counts per minute or cpm) can be converted to disintegrations per minute or dpm.

Immediately notify the RSO if you find unexpected levels.

RECORDS

Keep a record of dose rate and contamination survey results. It must include the following information:

- The date, area surveyed, and equipment used.

- The name or initials of the person who made the survey.

- A drawing of the areas surveyed with contamination and dose rate action levels as established by the RSO.

- Measured dose rates in mR/hr or contamination levels in dpm/100 cm², as appropriate.

- Actions taken in the case of excessive dose rates or contamination and follow-up survey information.

The Radiation Safety Office will review the record quarterly, and also promptly in those cases in which action levels were exceeded.
SURVEY METERS

POSSESSION

At a minimum, the nuclear cardiology laboratory will maintain the following inventory of radiation survey meters:

- A ratemeter with a thin window GM detector (e.g., Ludlum Model 14c with 44-7 or 44-9 probe or similar)

CALIBRATION

Survey meters must be sent to a licensed calibration laboratory at intervals not to exceed 12 months or after any servicing that may affect its calibration. Records of the calibration must be maintained. Before the survey meter is sent out for calibration, availability on site of a backup survey meter will be confirmed.
RADIATION WORKER TRAINING

Each new radiation worker is to receive an orientation on safe radiation practice before commencing work with sources of radiation and will receive instruction annually thereafter.

The supervisor of the worker is responsible for assuring that worker receives proper orientation which includes:

- **For all personnel:**
  - b. Role of time, distance, and shielding.
  - c. Personnel pregnancy procedures.
  - d. Need to keep entry to laboratories, hot rooms or waste storage areas locked at all times when unattended.
  - e. Use of radiation shielding.
  - f. DEP and 10CFR19 rights.
  - g. Importance of contamination control.
  - h. Care of issued personnel dosimeters.

- **For nuclear medicine workers:**
  - a. 10 CFR 19, 20, and 35 provisions.
  - b. Radiation level survey and wipe test procedures.
  - c. Gamma camera quality control.
  - d. Dose calibrator checks.
  - e. Need for doors to remain closed and hot lab door locked (security issues).
  - f. Disposal procedures.
  - g. Written directives and therapy procedures.
  - h. Pregnant patient procedures.

- **Ancillary personnel:**
  - a. Recognition of radiation warning signs as well as shipping labels on boxes.
  - b. Assuring that doors are locked behind them when leaving radioactive materials handling rooms and laboratories.
  - c. Not to enter areas designated as “Caution Radiation Area” or “Caution High Radiation Area”.
  - d. Contact Radiation Safety Office when in doubt.
NUCLEAR CARDIOLOGY TECHNOLOGIST SCOPE OF PRACTICE

Under the general supervision of the Nuclear Cardiologists, the Technologist:

- Operates and maintains quality control for all imaging equipment and radioactivity assaying devices; calibrates cameras and equipment in accordance with internal protocols and manufacturer’s instructions; verifies proper operation of equipment prior to use; checks radiation-monitoring devices and advises appropriate parties if problems are identified.

- Schedules patients for nuclear medicine examinations ensuring appropriate sequence of multiple procedures, questions patients and/or reviews patient charts for facts of patient history which are pertinent to interpretation of nuclear medicine examinations by the physician.

- Assumes care for physical and psychological needs of patient of all ages during an examination; initiates life support measures for patient, if necessary; and provides information to patient, family and/or guardian regarding any necessary precautions to take following procedure.

- Monitors patient vital signs. Perform EKG prep, tracing and monitors for obvious change during cardiac studies.

- Orders radiopharmaceuticals based on patient schedule; receives, packages containing radiopharmaceuticals and performs required surveys; prepares empty packages for return to the radiopharmacy in accordance with DOT regulations.

- Prepares radiopharmaceuticals for patient use, administers radiopharmaceuticals to patients and performs nuclear medicine procedures; ensures that sufficient supplies are on hand to perform procedures; follows safeguards and protocols to ensure quality of results.

- Operates nuclear medicine computer(s) to enhance the diagnostic value of information obtained from nuclear medicine procedures; follows internal protocols when processing computer studies to achieve high quality images by choice of filters, slice selection, display parameters, image intensity and labeling techniques.

- Maintains records and logs as required by department protocols, license requirements and regulating bodies (e.g., NRC, JCACO, PA DEP); logs patient dose administered, progress notes and other pertinent data.

- Disposes of and stores radioactive materials as required by law; stores radioactive materials/waste in appropriately labeled and shielded containers; removes radioactive and waste materials from exam rooms to proper storage or disposal location; surveys waste leaving the 'hot' lab for radiation levels in excess of established standards.

- Monitors Department with portable radiation detection survey meter for possible contamination. Maintain records of order, receipt, and disposal of all radioactive material.
RECEIPT OF PACKAGES CONTAINING RADIOACTIVE MATERIAL

GENERAL

Radioactive materials are delivered directly to Nuclear Cardiology by the courier. Nuclear Cardiology personnel log in and make appropriate measurements of the package.

PROCEDURES FOR RECEIPT OF RADIOACTIVE MATERIAL

- Put on disposable protective gloves (e.g., latex, nitrile) to prevent hand contamination.
- Visually inspect the package for outward signs of possible contamination such as physical damage to the package, package integrity (e.g., security seals), wet marks, rattling sounds etc.
- Measure the exposure rate from package at one meter and at surface.

<table>
<thead>
<tr>
<th>Label</th>
<th>Maximum Surface Dose Rate</th>
<th>Maximum Dose Rate at 1 meter*</th>
<th>Maximum Surface Contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Radioactive Label</td>
<td>0.5 mR/h</td>
<td>-</td>
<td>2200 dpm/100 cm²</td>
</tr>
<tr>
<td>Radioactive White I</td>
<td>0.5 mR/h</td>
<td>-</td>
<td>2200 dpm/100 cm²</td>
</tr>
<tr>
<td>Radioactive Yellow II</td>
<td>50 mR/h</td>
<td>10 mR/h</td>
<td>2200 dpm/100 cm²</td>
</tr>
<tr>
<td>Radioactive Yellow III</td>
<td>200 mR/h</td>
<td>10 mR/h</td>
<td>2200 dpm/100 cm²</td>
</tr>
</tbody>
</table>

*The reading at 1 meter should match the Transport Index on the package label.

- Contact the RSO IMMEDIATELY if radiation or contamination levels listed above are exceeded, so that the appropriate regulatory agencies and the courier can be notified.
- Monitor the package within 3 hours of receipt. If the package arrives after/before normal work hours monitor it within 3 hours of the start of the next business day.
- Open package and inspect contents to determine whether the correct isotope, activity and chemical/physical form was received.
- Check integrity of source container. Look for broken seals, vials, and loss of liquid, condensation or discoloration.
- Remove radioactive material from the packaging material.
- Log in shipments and measurement results. Information to be logged includes:
  - Date received
  - Amount (activity) received
  - Isotope
  - Vendor/shipper/radiopharmacy
  - D.O.T. Labeling (e.g., white I, yellow II)
  - Any damage to package
  - Wipe results (in dpm per 100 cm²)
  - Dose rate measurement results (in mR/h)
- For disposable packaging material (e.g., cardboard boxes), survey the packaging material for removable contamination (inside and outside of the package).
  - If contamination in excess of 200 dpm/100 cm² is present, discard the packaging material as radioactive waste.
If it is not contaminated, obliterate any radioactive labels or markings and dispose of the packaging material in regular trash.

- For empty packaging material (e.g., ammo box) that will be returned to the vendor, survey the packaging material for contamination (inside and outside of the package) and decontaminate to less than 200 dpm/100 cm$^2$. (This may be done by storing for decay if the half life is short.)
- In case of any questions or doubts, call the Radiation Safety Office.
APPENDIX

FORMS

PADEP Notice to Employees
Radiation Emergency Instructions
General Radiation Safety
Radiation Worker Registration
Authorization for Release of Radiation Exposure History
Guidelines for Nursing Mothers
NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION: NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS; EMPLOYEE PROTECTION

In Title 25 of its Rules and Regulations, the Pennsylvania Department of Environmental Protection has established standards for your protection against radiation hazards and has established certain provisions for the options of workers engaged in work under a Department license or registration.

YOUR EMPLOYER'S RESPONSIBILITY

Your employer is required to:
1. Apply these Department of Environmental Protection regulations and any conditions of your employer's radioactive materials license to all work involving radiation sources.
2. Post or otherwise make available to you a copy of the Department of Environmental Protection regulations, licenses, and operating procedures which apply to work in which you are engaged and explain these provisions to you.
3. Post Notice of Violation involving radiological working conditions, proposed imposition of civil penalties and orders.

YOUR RESPONSIBILITY AS A WORKER

You should familiarize yourself with these provisions of the Department of Environmental Protection regulations and operating procedures which apply to the work in which you are engaged. You should observe these provisions for your own protection and protection of your co-workers. If you observe a violation or possible safety concern, you should report it immediately to your supervisor or contact DEP. You may be personally subject to enforcement action if through deliberate misconduct you cause or attempt to cause a violation of DEP requirements or deliberately provide inaccurate or incomplete safety information to DEP or your employer.

WHAT IS COVERED BY THESE REGULATIONS

1. Limits on exposure to radiation and radioactive materials in restricted and unrestricted areas.
2. Measures to be taken after accidental exposure.
3. Personal monitoring, surveys, and equipment.
4. Caution signs, labels, and safety interlock equipment.
5. Exposure records and reports.
6. Options for workers regarding Department inspections.
7. Related matters.

REPORTS ON YOUR RADIATION HISTORY

1. The Department of Environmental Protection regulations require that your employer give you a written report if you receive an exposure in excess of any applicable limit as set forth in the regulations or the license. The basic limits for exposure to employees are set forth in Chapter 219 of the regulations. This chapter specifies limits on exposure to radiation and exposure to concentrations of radioactive material in air.
2. If you work where personal monitoring is required pursuant to Chapter 219:
   (a) Your employer must advise you annually of your exposure to radiation, and
   (b) You may request a written report of your radiation exposure when you leave your job.

INSPECTIONS

All activities involving radiation are subject to inspection by representatives of the Pennsylvania Department of Environmental Protection. In addition, any worker or representative of employees who believes that there is a violation of the Department regulations or of the terms of the employer's license or registration with regard to radiological working conditions in which the worker is engaged may request an inspection by sending a notice of the alleged violation to the Bureau of Radiation Protection. The request must set forth the specific grounds for the notice and must be signed by the worker or the representative of the workers on their behalf. During inspections, Department inspectors may confer privately with workers, and any worker may bring to the attention of the inspectors any past or present condition which he believes contributed to or caused any violation as described above.

INQUIRIES

Inquiries dealing with matters outlined above or other reports and correspondence can be sent to the Bureau of Radiation Protection, Pennsylvania Department of Environmental Protection, P.O. Box 6408, Harrisburg PA 17105-6408.

Telephone (717) 787-3720
Facsimile (717) 783-6965
Off hours emergency call PEMA: (717) 651-2001

POSTING REQUIREMENTS

Copies of this notice must be posted in a sufficient number of places in every establishment where activities covered by the regulations are conducted to permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.
Radiation Emergency Instructions

MINOR SPILLS* involving no radiation hazard to personnel.

1. **Notify** all other persons in the room or area that a spill has occurred.
2. **Prevent spread of contamination** by covering the spill with absorbent paper.
3. **Decontaminate** the area. Using paper towels or absorbent pads, clean towards the center of the spill. Place all waste into plastic bag and dispose as radioactive waste. Disposable gloves, lab coat, and if appropriate, shoe covers should be worn. Cleansing agents may be used after initial decontamination attempt.
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 Radiation Safety Office 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 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**: prevent entry into the room.
4. **Call for help**: Immediately contact Radiation Safety.
5. **Decontaminate personnel**: Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by Radiation Safety. Contaminated skin should be flushed thoroughly and then washed with mild soap and lukewarm water.

FIRES

1. **Rescue** persons in immediate danger
2. **Alarm** - activate manual pull station and call Security with the fire location.
3. **Contain** the fire by closing the room.
4. **Evacuate** the area. Do not attempt to extinguish the fire unless:
   a) The fire presents an immediate risk of injury to you or someone else in the area; or
   b) The fire is very small in size, easily extinguished, and you have had fire extinguisher training.

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

<table>
<thead>
<tr>
<th>During normal working hours Radiation Safety can be reached at the following numbers:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Number:</strong> 215-762-4050</td>
</tr>
<tr>
<td><strong>Radiation Safety Officer:</strong> 215-255-7860, cell phone:</td>
</tr>
<tr>
<td>215-651-2211</td>
</tr>
<tr>
<td><strong>RSO Staff:</strong> 762-3411, 762-6494</td>
</tr>
</tbody>
</table>

*After hours, call operator and request activation of the radiation emergency call list.*

**A spill is defined as leaving the confines of the experiment. A discharge onto absorbent paper or a drip tray is not a spill.**
**General Radiation Safety**

- Wear laboratory coats or other protective clothing at all times in areas where radioactive materials are used.
- Wear disposable gloves at all times while handling radioactive materials.
- Periodically throughout the workday, and before leaving the area at the end of the day, monitor your hands for contamination in a low-background area with an appropriate detection instrument.
- Use syringe shields for routine preparation of multi-dose vials and administration of radiopharmaceuticals to patients, except in those circumstances in which their use is contraindicated (e.g., recessed veins, infants). In these exceptional cases, consider the use of other protective methods such as remote delivery of the dose (e.g., through use of a butterfly valve).
- Do not eat, drink, smoke, or apply cosmetics in any area where radioactive material is stored or used.
- Do not store food, drink, or personal effects in areas where radioactive material is stored or used.
- Wear personal monitoring devices at all times while in areas where radioactive materials are used or stored. These devices should be worn as prescribed by the Radiation Safety Officer. When not being worn to monitor occupational exposures, personal monitoring devices should be stored in the work place in a designated low-background area.
- Wear a finger exposure monitor during the elution of generators; during the preparation, assay, and injection of radiopharmaceuticals; and when holding patients during procedures.
- Dispose of radioactive waste only in designated, labeled, and properly shielded receptacles.
- Never pipette by mouth.
- Wipe-test radioactive material storage, preparation, and administration areas weekly for contamination. If necessary, decontaminate or secure the area for decay.
- With a radiation detection survey meter, survey the generator storage, kit preparation, and injection areas daily for contamination. If necessary, decontaminate or secure the area for decay as appropriate.
- Confine radioactive solutions in shielded containers that are clearly labeled.
- Radiopharmaceutical multidose diagnostic vials and therapy vials should be labeled with the isotope, the name of the compound, and the date and time of receipt or preparation. A log book should be used to record the preceding information and total prepared activity, specific activity as mCi/cc at a specified time, total volume prepared, total volume remaining, the measured activity of each patient dosage, and any other appropriate information. Syringes and unit dosages should be labeled with the radiopharmaceutical name or abbreviation, type of study, or the patient's name.
- Assay each patient dosage in the dose calibrator before administering it. Do not use a dosage if it is more than 10 percent off from the prescribed dosage. When measuring the dosage, you need not consider the radioactivity that adheres to the syringe wall or remains in the needle. Check the patient's name and identification number and the prescribed radionuclide, chemical form, and dosage before administering.
- Always keep flood sources, syringes, waste, and other radioactive material in shielded containers.
- Because even sources with small amounts of radioactivity exhibit a high dose rate on contact, you should use a cart or other transportation method to move flood sources, waste, and other radioactive material.
Radiation Worker Registration

Name: ___________________________  ___________________________  Birth date: _____/_____/______  Gender:  □ M  □ F

Title/Position: ___________________________  Employee ID#: ___________________________  Last 4 digits of SSN ________

Department: ___________________________  Supervisor: ___________________________

Employer (e.g., DU, DUCOM, SCHC, CTCA): ___________________________  Building: ________________  Room: ______

Exposure

[ ] Directly with unsealed sources of radioactive material (e.g., liquids)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Activity (mCi)</th>
</tr>
</thead>
</table>

[ ] Directly with sealed sources of radioactive material (e.g., brachytherapy sources)

[ ] Directly with radioactive material in a device (e.g., blood irradiator)

Device: ___________________________

[ ] Directly with x-ray producing machines. Unit Type: ___________________________

[ ] Incidentally exposed to sources of radiation (e.g., nurses caring for therapy patients, anesthesiologists)

Describe source of exposure: ___________________________________________

[ ] Other (describe): ___________________________________________

Training

List any radiation safety training courses that you have attended.

<table>
<thead>
<tr>
<th>Institution/Company</th>
<th>Course Name / Topic</th>
<th>Clock Hours</th>
<th>Approximate Date</th>
</tr>
</thead>
</table>

Certifications

List any applicable certifications which demonstrate competency using radioactive material/radiation (e.g., CNMT, RTT)

<table>
<thead>
<tr>
<th>Certification</th>
<th>Certifying body</th>
<th>Date</th>
</tr>
</thead>
</table>

Experience

List all previous employment with exposure to radiation. If no previous experience, indicate "NONE."

<table>
<thead>
<tr>
<th>Institution / Company</th>
<th>City</th>
<th>State</th>
<th>Source(s) Used</th>
<th>Quantity (if applicable)</th>
<th>Dates</th>
</tr>
</thead>
</table>

Radiation Exposure History

Indicate your approximate radiation dose in millirem for the current calendar year.

<table>
<thead>
<tr>
<th>Deep Dose (whole body)</th>
<th>Shallow Dose (skin)</th>
<th>Extremity</th>
<th>Eye</th>
<th>Committed Organ Dose Equivalent</th>
<th>Total Effective Dose Equivalent</th>
</tr>
</thead>
</table>

Have you been assigned a planned special exposure as defined by the NRC?  □ no  □ yes

Signature: ___________________________  Date: ___________________________
Authorization to Release Radiation Exposure History to
Drexel University Radiation Safety Office

Name: _____________________________

ID # (eg. Drexel ID): ___________________

Alternate name for records (e.g., maiden name): __________________________

Authorization to release my radiation exposure records to Drexel University Radiation Safety Office is hereby granted. Photocopies of this release authorization are acceptable.

Signature: __________________________     Date: _______________________

RSO Use Only

<table>
<thead>
<tr>
<th>Institution</th>
<th>Request Date</th>
<th>Follow-up 1</th>
<th>Follow-up 2</th>
<th>Received</th>
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</thead>
<tbody>
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</table>
Guidelines for Nursing Mothers Receiving Radiopharmaceuticals

This brochure is provided to give you special instructions about breastfeeding after you have undergone a nuclear cardiology study. You were given a radioactive drug. The amount of radioactive drug that passes through your body and into breast milk depends on the drug administered to you.

On __________________, you received/will receive ______ mCi of the radiopharmaceutical, ________________________________, for a ___________________________ study.

By following the marked instruction below, you will avoid unnecessary radiation exposure to your infant or child from radioactive material in breast milk.

**Breastfeeding Instructions:**

- No interruption of breastfeeding is necessary.
  - Tc-99m Red blood cells in vitro labeling (<30 mCi)

- Do not breastfeed for 2 hours after your study.
  - Tc-99m PYP (20 mCi)

- Do not breastfeed for 4 hours after your study and restrict close contact for 4 hours.
  - Tc-99m Myoview (30 +10 mCi)
  - Tc-99m Cardiolite (30 +10 mCi)

- Do not breastfeed for 6 hours after your study and restrict close contact for 4 hours.
  - Tc-99m Red blood cell in vivo labeling, (10 - 20 mCi)

- Do not breastfeed for 9 hours after your study and restrict close contact for 4 hours.
  - Tc-99m Red blood cell in vivo labeling, (20 - 30 mCi)

- Do not breastfeed for 12 hours after your study.
  - Tc-99m Pertechnetate (3 - 12 mCi)

- Do not breastfeed for 24 hours after your study.
  - Tc-99m Pertechnetate (12 - 30 mCi)

- Do not breastfeed for 2 weeks after your study.
  - TI-201 Chloride (1 - 3 mCi)

If interruption of breast-feeding is necessary it may be possible to pump milk prior to the procedure and to store one or more feedings in a refrigerator or freezer. The child should be fed naturally prior to administration of the radiopharmaceutical dose. During the period of interruption recommended above, you should regularly express and discard your milk.