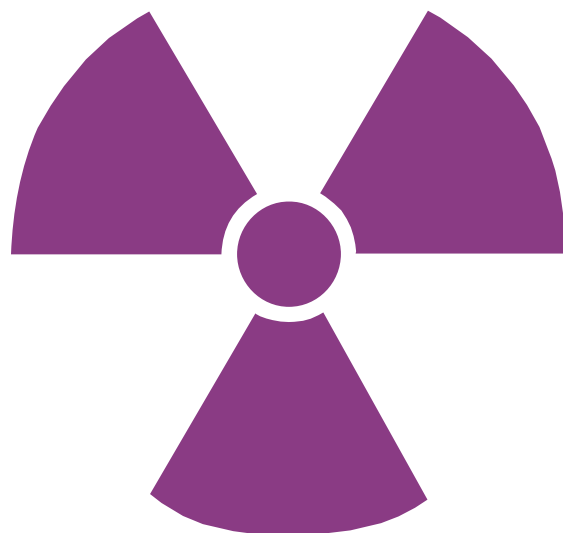


VANDERBILT UNIVERSITY



RADIATION SAFETY POLICIES & PROCEDURES MANUAL

VANDERBILT ENVIRONMENTAL HEALTH & SAFETY
www.safety.vanderbilt.edu

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Introduction

This manual is issued to provide users of ionizing radiation with information on the policies and procedures of the Vanderbilt University radiation safety program. Activities involving radiation sources are conducted under licenses and registrations issued by the State of Tennessee Department of Environment and Conservation, Division of Radiological Health. Vanderbilt Environmental Health and Safety (VEHS) administers the radiation safety program at Vanderbilt. Vanderbilt's Radiation Safety Committee establishes policies governing the use of radiation sources and approves users. Although the Radiation Safety Committee approves authorized user physicians, the Human Subjects Radiation Committee (HSRC) or the Radioactive Drug Research Committee (RDRC) must approve all research uses of radiation involving humans. All users must comply with the rules set forth in this manual. A copy of this manual must be maintained in a location convenient and accessible to radiation workers at all times.

Acronyms

ALARA	As Low As Reasonably Achievable
ALI	Annual Limit on Intake
FDA	Food and Drug Administration
HSRC	Human Subjects Research Committee
IND	Investigational New Drug
IRB	Institutional Review Board
LSC	Liquid scintillation counter
PI	Principal Investigator
RDRC	Radioactive Drug Research Committee
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
SRPAR	State Regulations for Protection Against Radiation
TVL	Tenth Value Layer
VEHS	Vanderbilt Environmental Health and Safety

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Section 1: Functions and Responsibilities

A. The Radiation Safety Committee (RSC)

Charge. The Committee will:

1. Ensure that radioactive material licensed under the broadscope radioactive material license, and ionizing radiation-producing equipment (i.e. x-ray equipment, fluoroscopes, accelerators, etc.) are used safely, and in compliance with State of Tennessee and federal regulations, broadscope license conditions, and certified registrations;
2. Review and approve or disapprove users and uses of licensed material;
3. Review recommendations on ways to maintain individual and collective doses as low as reasonably achievable (ALARA);
4. Review quarterly, a summary of the occupational radiation dose records (ALARA report) of all personnel working with licensed material;
5. Review quarterly all incidents involving licensed materials with respect to cause and subsequent actions taken;
6. Review annually the radiation safety program.

Responsibilities. The Committee shall:

1. Be familiar with all pertinent state regulations, registrations, the license application, the license, and amendments;
2. Review the training and experience of the proposed principal investigators, and the Radiation Safety Officer (RSO) to determine that their qualifications are sufficient to enable the individuals to perform their duties safely and are in accordance with the regulations, registrations, and the license;
3. Review on the basis of safety and approve or deny, consistent with the limitations of the regulations, registrations, the license, and the ALARA philosophy, all requests for authorization to use radioactive material or electrically generated ionizing radiation within the institution;
4. Prescribe special conditions that will be required during a proposed method of use of radioactive material such as requirements for bioassays, physical examinations of users, and special monitoring procedures;
5. Review quarterly the RSO's summary report of the occupational radiation exposure records of all personnel, giving attention to individuals or groups of workers whose occupational exposure appears excessive;

6. Establish a program to ensure that all persons whose duties may require them to work in or frequent areas where radioactive materials are used (e.g., nursing, security, housekeeping, physical plant) are appropriately instructed as required in 1200-2-4-.12 in the State Regulations for Protection Against Radiation (SRPAR);
7. 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 state regulations, registrations, and the conditions of the license, and consistent with the ALARA program and philosophy. The review must include an examination of records, reports from the RSO, results of state inspections, written safety procedures, and the adequacy of the management control system;
8. Recommend remedial action to correct any deficiencies identified in the radiation safety program;
9. Maintain written minutes of all Committee meetings, including members in attendance and members absent, discussions, actions, recommendations, decisions, and numerical results of all votes taken;
10. Ensure that the radioactive material license is amended if required prior to any changes in facilities, equipment, policies, procedures, and personnel.

B. Human Subjects Radiation Committee (HSRC)

The HSRC is a subcommittee of the Institutional Review Board (IRB). This committee reviews proposals involving research uses of radioactive material or ionizing radiation-producing devices in or on humans. The HSRC also functions as the Radioactive Drug Research Committee and reviews proposals that qualify under FDA rules for submission to this committee.

C. Vanderbilt Environmental Health and Safety (VEHS)

VEHS will:

1. Order, receive, and deliver radioactive materials;
2. Manage radioactive waste;
3. Perform laboratory audits and surveys;
4. Perform instrument calibration/performance checks;
5. Provide personnel monitoring/bioassay services;
6. Provide radiation safety support for therapeutic applications;
7. Perform inventory/leak test/survey requirements for sealed sources;
8. Provide Radiation Safety Training;

9. Maintain emergency preparedness;
10. Maintain records;
11. Provide advice and consultation to faculty, on matters related to radiation safety;
12. Monitor radiation users for compliance with State and Federal regulations, license conditions, and policies of the Radiation Safety Committee;
13. Inspect accelerators and x-ray machines for compliance with State regulations;
14. Provide administrative support for the RSC;
15. Provide initial review of proposals submitted to the RSC;
16. Prepare and ship all radioactive materials sent to Vanderbilt.

D. Radiation Safety Officer

The Radiation Safety Officer will:

1. Manage the radiation safety program
2. Identify radiation safety problems
3. Initiate, recommend, or provide corrective actions
4. Verify implementation of corrective actions
5. Ensure compliance with regulations
6. Assist the RSC in the performance of its duties
7. Suspend any operation that is found to be a serious threat to health or property
8. Submit plans for new buildings and modifications of existing structures where ionizing radiations are to be used to the Radiation Safety Committee for approval prior to construction or modification

E. Principal Investigator

The Principal Investigator will:

1. Update all changes in the use of radioactive material with VEHS;
2. Ensure proper receipt/storage of radioactive material;

3. Ensure proper use of radioactive material by individuals who meet Vanderbilt's Radiation Safety training requirements;
4. Limit use of radioactive materials to individuals working under their authorization;
5. Ensure appropriate personnel and area monitoring are performed for radioactive material use;
6. Ensure proper disposal of radioactive waste;
7. Ensure all records of inventory, use, disposal, and surveys are maintained;
8. Ensure workers are familiar with radioactive material spill procedures;
9. Notify VEHS when terminating the use of radioactive material for close out surveys/documentation;
10. Encourage and promote As Low As Reasonably Achievable (ALARA) principals;
11. Communication to VEHS of information regarding changes in operational procedures or facilities which might lead to increased personnel exposure or contamination levels in the laboratory or the environment;
12. Ensure compliance with the Radiation Safety Policies and Procedures Manual;
13. Instruction of employees in the use of safety devices and procedures;
14. When Principal Investigators leave the University, they are required to account for and dispose of all radioactive material and effect any necessary decontamination of laboratory facilities. The Principal Investigator's department must assume these responsibilities if the PI leaves before resolving these matters.

To assist in ensuring that these responsibilities are met, the PI may choose to appoint a Radiation Safety contact person for the laboratory who will ensure day-to-day compliance in the laboratories of the approved user. VEHS provides supplemental training for Radiation Safety contacts to help them review documentation requirements and perform area surveys.

F. Radiation Workers:

Radiation Workers will:

1. Work in a manner that will minimize radiation exposure to themselves, fellow workers, and the general public.
2. Conduct surveys, when working with radioactive material, to assure that radiation levels are As Low As Reasonably Achievable (ALARA). Radiation workers are expected to maintain their radiation exposure As Low As Reasonably Achievable (ALARA).

3. Know and adhere to the Radiation Safety Policies and Procedures Manual and any specific radiation safety procedures that are applicable to their work.
4. Have Radiation Safety Training and Orientation documented with VEHS.
5. Report incidents involving contamination of personnel, unconfined spills, theft or loss of radioactive material, and suspected overexposures to VEHS immediately.
6. Be responsible for posting radiation work areas and properly identifying these materials and any contaminated equipment.
7. Be familiar with the characteristics of the radioactive materials they are using.
8. Be responsible for understanding how survey meters work and which survey meters will detect the radiation they are using.
9. Be familiar with radiation survey procedures and are responsible for surveying work areas for contamination periodically and after each radioisotope procedure. They are responsible for surveying hands, body, and clothing for contamination. If radiation workers are contaminated contact VEHS at 322-2057 or 835-4965 and confine the contaminated workers.
10. Be responsible for the proper use and handling of their personnel monitoring badges, for furnishing bioassay samples to VEHS for analysis when requested, and for obtaining periodic thyroid uptake measurements when working with radioiodine.
11. Be responsible for the proper disposal of their radioactive waste and for maintaining records of all disposals.
12. Be familiar with decontamination procedures and are responsible for the cleanup of any contamination that they created.
13. Wear radiation badges at all times when working with or in the vicinity of sources of ionizing radiation, if a radiation badge has been assigned to them.

Section 2: Obtaining Authorization to Use Radioactive Materials

A. Application Procedure

Application forms may be obtained from VEHS or downloaded from the VEHS website www.safety.vanderbilt.edu . Criteria, guidelines, and instructions are included with the forms. Applications are initially reviewed by VEHS staff and then submitted to the RSC for review.

B. Qualifications

1. Principal Investigator

- a. The Principal Investigator must normally be a full-time faculty member.
- b. The Principal Investigator must have a college degree at the bachelor level, or equivalent training and experience, in the physical or biological sciences or in engineering
- c. The Principal Investigator must have training and experience in the safe handling of radioactive materials, and in the characteristics of ionization radiation, units of radiation dose and quantities, radiation detection instrumentation, and biological hazards of exposure to radiation appropriate to the type and forms of radioactive materials to be used.
- d. The Principal Investigator cannot be visiting faculty, residents, or fellows.

2. Authorized User Physicians

The physician must meet the following criteria:

- a. The Authorized User must be a physician, dentist, or podiatrist licensed to practice medicine in the State of Tennessee.
- b. Authorized Users who use radioactive materials for human use must meet the training requirements outlined in Appendix A “Acceptable Training and Experience for Medical Uses of Radioactive Material”.
- c. Each Authorized Users Physician who administers or supervises the administration of radioactive materials or ionizing radiation from radioactive materials to humans must be approved by the RSC.

3. Authorized Nuclear Pharmacist

The pharmacist must meet the following criteria:

- a. The Authorized User Pharmacist must be a pharmacist licensed to practice pharmacy in the State of Tennessee.

- b. Authorized User Pharmacists must meet the training requirements outlined in Appendix A “Acceptable Training and Experience for Medical Uses of Radioactive Material”.
- c. Each Authorized Users Pharmacist must be approved by the RSC.

C. Additional Requirements for Human Use

Authorized User Physicians wanting to perform research must also obtain approval from the HSRC/RDRC subcommittees of the IRB for each protocol. Research includes phase I, II, or III clinical trails, off label use of FDA approved radiopharmaceuticals, research protocol in which normals are exposed to radiation sources, human subjects receiving radiation from a procedure that is not part of standard care.

D. Renewal

All radioactive material approvals must be renewed and updated annually. VEHS will mail a renewal to each PI in January of each year.

E. Amendments

1. Significant changes (i.e. increases in possession limits, addition/deletion of radionuclides) to the radioactive materials authorizations must be approved by the RSC. When amending an application that is more than 5 years old, the PI is required to submit a complete updated application that includes all previously approved radioisotopes and usages.
2. Minor amendments that meet the following criteria can be administratively approved by the RSO:
 - a. Possession limit increase less than or equal to 20% of the current possession limit or one exempt quantity, which ever is greater.
 - b. The addition of a radionuclide with a possession limit not exceeding one exempt quantity.
 - c. Substitution of ^{33}P for ^{32}P or ^{35}S . The ^{33}P possession limit cannot exceed the current possession limit for ^{32}P or ^{35}S .

F. Leave of Absence

In the event that a PI takes a leave of absence, the authorization will remain in effect provided the PI appoints a suitably qualified individual to supervise operations during the PI's absence. This individual should be approved by the RSC before the leave of absence.

Section 3: Personnel Monitoring

A. Occupational Dose Limits

The State of Tennessee requires monitoring of individuals' radiation exposure if it is expected that a person will receive a dose in excess of 10%. The annual occupational dose limits for an adult radiation worker are given in Table 1:

Table 1: Occupational Dose Limits for Adults

Description	Dose Limit
Whole Body	5,000 mrem/yr (50 mSv/yr)
Skin	50,000 mrem/yr (500 mSv/yr)
Extremity	50,000 mrem/yr (500 mSv/yr)
Any organ other than the lens of the eye	50,000 mrem/yr (500 mSv/yr)
Lens of the eye	15,000 mrem/yr (150 mSv/yr)

The annual occupational dose limits for minors are 10% of the limits for adult radiation workers. Therefore, minors have a whole body occupational dose limit of 500 mrem/yr (5 mSv/yr). Radiation badges are required if an individual is expected to receive 10% of the applicable limit, for minors this corresponds to 50 mrem/yr (0.5 mSv/yr). All minors who work with sources of ionizing radiation or in a laboratory using radioactive material are required to wear a dosimeter.

The dose limit for an embryo/fetus of a declared pregnant woman is 500 mrem (5 mSv) for the entire gestation period and the dose should not exceed 50 mrem/month (0.5 mSv/month). These limits can only be enforced if the pregnancy is declared. A declared pregnant woman is defined as a woman who has voluntarily informed her employer in writing of her pregnancy and the estimated date of conception. Declaration forms and counseling are available from VEHS, the VEHS web site www.safety.vanderbilt.edu, or Occupational Health Services. The pregnancy declaration form must be submitted to Occupational Health Services.

Permanent copies of personnel dosimetry records are maintained by VEHS. Copies are also distributed monthly to the various departmental badge representatives.

B. Personnel Dosimeters

VEHS will issue radiation badges commensurate with the type of ionizing radiation being used. Radiation badges are issued to workers who are likely to exceed 10% of the occupational dose limits. Workers may work with radioactive material and not be issued a radiation badge. Radiation badges will be issued based on the following: 1) VEHS analysis of potential radiation exposure, 2) the type of radiation emitted from the radioactive material, 3) the quantity of radioactive material handled, and 4) the handling time. Badge applications may be obtained from VEHS, the VEHS web site www.safety.vanderbilt.edu, or the badge representative. Permanent records of personnel exposures are maintained by VEHS. Employees can review and discuss their radiation exposure records with VEHS staff.

C. Responsibilities for Personnel Dosimeter Users

1. The badge reading is a legal record and must reflect occupational exposure only. Therefore, the badge shall be worn only by the person to whom it was assigned, and shall not be tampered with or experimentally irradiated, and shall not be used to measure any radiation exposure you may receive as a medical patient.
2. Badges are distributed and collected by departmental badge representatives on a monthly exchange frequency. It is your responsibility to exchange your badge on time with your badge representative.
3. Radiation workers assigned a badge must have complete records of their occupational exposure for the current year, i.e. no "gaps" are allowed in their personnel dosimetry records. If a badge is lost, a replacement badge must be obtained from VEHS and a Missing Badge Report completed so that an estimated exposure may be assigned.
4. Badges should be worn on chest, collar, or belt so as to indicate "whole body" exposure. If a lead apron is worn the badge should be worn at collar level outside the apron so that exposure to the head is monitored.
5. Ring badges should be worn on the palm side of the hand to best monitor the exposure received from handling radionuclides. If wearing gloves to prevent contamination to the hands, the ring badge should be worn *under* the gloves.
6. Badges should not be left near a source of heat. At the end of the work day badges should be left in a location where they will not be exposed to radiation or heat.
7. Persons issued a dosimeter must wear it at all times when working with sources of ionizing radiation.

D. Bioassays

1. Thyroid Monitoring Requirements for Unsealed Sources of Radioiodine

Before handling quantities of radioiodine exceeding 10% of the values given in Table 2 an individual must have a baseline thyroid bioassay. A thyroid bioassay is required when an individual handles unsealed quantities of radioiodine that exceed those shown in Table 2. The thyroid bioassay must be performed within ten days after handling the radioiodine.

Table 2: Thyroid Bioassay Requirements

Type of Operations	Volatile Form	Bound to Nonvolatile Agent
Processes on open bench, with possible escape of iodine from process vessels	1 mCi (37 MBq)	10 mCi (370 MBq)
Processes carried out in adequate fume hood	10 mCi (370 MBq)	100 mCi (3.7 GBq)

Note: Quantities are considered to be the cumulative amount in processes handled by a worker during a 3 month period. Capsules (such as gelatin capsules given to patients for diagnostic tests) may be considered to contain radioiodine in nonvolatile form.

Bioassay Requirements for Nuclear Medicine Personnel:

Nuclear Medicine personnel who handle (or administer) less than 30 mCi (1.11 GBq) of Na¹³¹I in capsule form are required to have a thyroid bioassay at least once per calendar quarter, or 30 mCi (1.11 GBq) or more of Na¹³¹I in capsule form are required to have a thyroid bioassay within ten days after handling the radioiodine.

Enforcement:

Failure to comply will result in a termination of ordering privileges for the PI.

Time and Location of Measurements:

Call VEHS (2-2057) to schedule a thyroid bioassay appointment.

Thyroid Action Levels:

Thyroid activities in excess of 0.00012 mCi (4.44 kBq) of ¹²⁵I or 0.000040 mCi (1.48 kBq) of ¹³¹I requires an investigation of the operations involved and the implementation of corrective action. Repeat thyroid bioassays will be required.

2. Tritium Bioassay Requirements

Individuals involved in operations that utilize, at any one time, more than 100 mCi (3.7 GBq) of ³H in a non-contained form, other than metallic foil, shall have urine bioassays performed within one week following a single operation and at weekly intervals for continuing operations. The assay frequency for continuing operations may be reduced to monthly after the first calendar quarter, dependent upon initial results.

3. Accidents

Bioassays may be required if a person has been involved in a spill or other incident in which there may have been a significant intake of radioactive material. Bioassays may include urinalysis, analysis of other excreta such as fecal samples and nose wipes, whole body or thyroid counts.

Section 4: Policies and General Procedures For Radioactive Material Use

A. General Safety Rules for Working with Radioactive Material

1. Prior to using Radioactive Material

- a. Be familiar with the procedure being performed; perform a “dry” run to identify any potential problems; seek supervision for initial run from an investigator experienced with that particular procedure.
- b. Ensure all needed equipment is available and functioning properly.
- c. Prepare the work area with absorbent paper (absorbent side up); use absorbent lined trays when possible.
- d. Prepare for spills. Familiarize yourself with decontamination procedures. You are responsible for decontaminating your own spills.
- e. Have decontamination supplies available.
- f. Post radiation work areas, laboratories, and containers of radioactive materials with appropriate warning signs.
- g. Volatile radioactive materials or operations where significant gases or vapor could be released must be conducted in a fume hood.

2. When Working with Radioactive Material

- a. Wear a lab coat or other protective clothing. Potentially contaminated laboratory coats should not be worn outside the laboratory.
- b. If assigned wear appropriate personnel monitoring devices.
- c. Wear gloves whenever handling unsealed radioactive material.
- d. Use remote handling tools and utilize appropriate shielding as indicated, plexiglass for ^{32}P , lead for ^{125}I , etc.
- e. Work in a fume hood if volatile materials are used.
- f. Secure all radioactive material when not in use.
- g. Do not eat, drink, smoke, or apply cosmetics in areas where radioactive material is used or stored.
- h. Do not pipette by mouth.
- i. Do not store food or beverages in a refrigerator designated as a radioactive materials storage facility.

- j. Use disposable absorbent pads or lipped trays to protect work surfaces and to confine spills.
- k. Hands should be checked often for contamination while working with radioactive material. If contamination is discovered, remove gloves and check hands.
- l. Limit as much as possible the amount of time spent handling radioactive material.
- m. Work with radioactive material should be confined to the work area.
- n. Radioactive materials should not be left in uncovered containers.
- o. All radioactive material containers should have the contents clearly labeled.
- p. Liquid radioactive material must be in a secondary container.

Additional Rules for Nuclear Medicine

- a. Syringe shields are required for preparation of patient doses and administration to patients.
- b. Finger badges must be worn during elution of the generator, and the preparation, assay, and injection of radiopharmaceuticals.
- c. Survey generator, kit preparation, and injection areas for contamination after each procedure or at the end of the day. Decontaminate if necessary.
- 4. Assay each patient dose in the dose calibrator prior to administration. Do not use any doses that differ from the prescribed dose by more than 10 %.

3. After Completion of Work with Radioactive Material

- a. Radioactive wastes must be placed in appropriately marked radioactive waste receptacles, contained in appropriate containers (bags or bottles), and VEHS notified of the need for collection (see Appendix C “Radioactive Waste Disposal”).
- b. Low level radioactive liquids may be disposed in designated “hot” sinks. Normally, low level radioactive liquids are rinse water and high volume low activity waste. Sink disposal is limited to 0.2 mCi per day per radionuclide.
- c. Monitor hands, shoes, clothing and work area with a survey meter.
- d. Janitorial and other maintenance workers shall be notified whenever special precautions are required for performing their duties in the lab such as when contaminated areas or unusually high radiation exposure levels exists.

The PI has the responsibility to protect both the workers and the general public from any radioactive sources being used. The PI should be familiar with the basic principals of radiation protection and the properties of the radioactive materials being used. The PI should see that the work of the group is properly planned and that adequate instructions are provided for any operations involving radioactive material. For lengthy, repetitive procedures, the instructions should be in written form. A dry test run should precede an initial unfamiliar procedure. The PI shall see that instructions are followed and that safety rules are enforced.

B. Maximum Radiation and Contamination Levels

1. Maximum Permissible Radiation Levels

- a. Radiation levels in unrestricted areas (i.e. areas with free access, no control over who comes and goes, such as in corridors) must be kept below both:
 - I. 2 mrem (0.02 mSv) in any one hour.
 - II. 100 mrem (1 mSv) per year.
- b. Radiation levels in restricted areas must be less than 5,000 mrem (50 mSv) per year

2. Maximum Permissible Contamination Levels

Radioactive contamination must not be allowed to remain above the limits given the Table 3. Items may be released for unrestricted use if they are below the contamination limits given in Table 3.

Table 3: Contamination Limits

Type of Contamination	Low Toxicity Radionuclide (dpm/100 cm²)	Moderate and High Toxicity Radionuclide (dpm/100 cm²)	Very High Toxicity Radionuclide (dpm/100 cm²)
Unrestricted areas and personal clothing	2,000	200	20
Restricted areas	10,000	1,000	200
Fixed contamination	10,000	1,000	200

Note: Toxicity classes for various radionuclides may be found in Appendix B “Table of Radionuclides”. Toxicity classes are defined in Table 4.

“Removable contamination” means radioactivity that can be transferred from a surface to wipe test paper by rubbing with moderate pressure.

Fixed contamination levels may be measured with a survey meter calibrated to read in mR/hr. The average and maximum radiation levels associated with surface contamination by beta-gamma emitters should not exceed 0.2 mR/hr with the detector 1 cm from the surface and 1.0 mR/hr with the detector 1 cm from the surface, respectively, as measured through not more than 7 mg/cm² of total absorber.

Table 4: Radionuclide Toxicity Class

Toxicity class is based on the Annual Limit on Intake (ALI)				
Toxicity Class	Low	Moderate	High	Very High
ALI (mCi)	>5	0.500-4.999	0.005-0.499	<0.005

C. Posting and Labeling requirements

1. Labs or areas where radioactive materials are used

A “Caution, Radioactive Materials” sign must be posted in any area where radioactive material is used or stored on a regular basis. If a PI no longer intends to use radioactive material in a given room/area, contact VEHS to close out the lab. VEHS will remove all “Caution, Radioactive Materials” signs after the area has been surveyed and decontaminated as appropriate.

2. Containers and equipment for radioactive material

All containers of radioactive material must be labeled with a “Caution, Radioactive Material” label. The label must also provide the radionuclide(s) present, an estimate of the activity, the date for which the activity is estimated, and kinds of material. This permits individuals handling or using the containers to take the necessary safety precautions. Any hazardous chemicals should also be identified on the label.

Any refrigerator, fume hood, incubator, or other equipment where radioactive materials are stored must be labeled. A refrigerator where radioactive materials are stored must be labeled with a “Caution, Radioactive Materials” or a “Caution Radioactive Materials No Food or Beverage May Be Stored in This Unit” sign. An incubator, fume hood, or other equipment must be posted with a “Caution, Radioactive Materials” sign. If the refrigerator, incubator, or other equipment will no longer be used with radioactive material, call VEHS to schedule an equipment check to survey the equipment for contamination and removal of the labels. If repairs need to be made to a radioactive materials refrigerator, fume hood, incubator, or other equipment, contact VEHS to schedule an equipment check to survey the equipment for contamination prior to repairs.

Any equipment such as a pipette, centrifuge, scale, etc. used with radioactive material should be posted with a “Caution, Radioactive Materials” label.

3. Sinks for disposal of liquid radioactive waste

If a PI wishes to dispose of radioactive material via the sanitary sewer, then the radioactive material must be readily soluble or readily biologically dispersible material in water. The sink designated for sanitary sewer disposal must be posted with a “Radioactive Hot Sink” sign. If repairs need to be made to the sink contact, VEHS to schedule a sink check to survey for contamination prior to repairs.

4. Radioactive waste containers

All radioactive waste containers must be posted with a “Caution, Radioactive Materials” or a “Radioactive Waste” sign. All full waste bags must be tagged with a radioactive waste tag. The waste tag must have the radionuclide, the estimated activity, the date of the estimated activity, the name of the PI, and a signature. If a waste container with radioactive waste has been emptied by Environmental Services, contact VEHS immediately (2-2057).

5. Signs and labels required for radioactive material use

It is the responsibility of the user to post the appropriate caution signs in all areas. The signs and labels will be initially supplied by VEHS; however, investigators should purchase their own if they have a continuing need. Catalogs and prices are available in the VEHS office. Please consult with the VEHS staff for any needed advice and assistance in posting and labeling. The Notice to Employees (see next page) must be posted in all areas where ionizing radiation is used.

D. Sealed Sources of Radioactive Material

1. Leak tests to check the integrity of sealed source encapsulation must be conducted at intervals not exceeding six months. If there is a reason to suspect that a source may be damaged, it must be tested before further use. This test is not required if the source is being stored and is not being used; however, such sources will require testing for leakage prior to any use or transfer. VEHS will perform all required leak tests. If the leak test reveals the presence of 0.000005 mCi (185 Bq) or more of removable contamination the source must be removed from use.
2. Sealed sources require leak testing if they meet the following criteria:
 - a. Half-life greater than 30 days
 - b. Nongaseous form
 - c. Activity greater than 0.100 mCi (3.7 MBq) for a beta or gamma emitter, or 0.010 mCi (370 kBq) for an alpha emitter
 - d. Not required for tritium
3. Sources obtained as sealed sources shall not be opened. The safety and handling precautions furnished by the manufacturer shall be maintained in a location that is readily available to all workers and followed.

E. Radiation Surveys

1. Types of Surveys

Surveys are performed to locate areas of increased exposure or removable contamination. Exposure surveys may identify areas with increased exposure or

contamination. A wipe survey is routinely performed to determine if removable contamination is present. If the area is contaminated, see decontamination procedures in this manual or call VEHS (322-2057).

A survey is required after each use of radioactive material. If the laboratory is classified as a medium hazard laboratory a survey is required to be documented weekly.

Surveys after each use of radioactive material shall include a survey of hands, clothing, equipment, and the work areas. A GM or NaI survey meter evaluation is required unless only tritium is used, then a wipe survey should be performed. If increased readings are detected with the survey meter, a wipe survey of the area should be performed.

Documented weekly surveys shall include all work areas, preparation areas, equipment storage areas, cabinet fronts, drawer fronts, desks, and those areas classified as “clean”. A GM or NaI scintillation meter for radioiodine evaluation and wipe surveys are required.

2. How to survey

Geiger Mueller (GM) survey instruments can be used to detect beta and gamma radiation. When using a GM survey meter remove any protective caps. The thin window should not be covered, as it will decrease detection sensitivity. Check the calibration sticker to ensure the meter has been calibrated within the last year. Do not use the meter if more than a year has past since the last calibration. Check the batteries and do a performance check on the meter to ensure it is functioning properly. A performance check may include the use of a dedicated check source or a vial or tube containing a known amount of radioactive material. Verify background is within an acceptable range, typically 0.01-0.05 mR/hr. If there are any questionable results, e.g. no response, or the meter will not zero, call VEHS for guidance.

To survey, slowly move the probe over the surface with the thin window facing the surface. The probe should be 1 centimeter above the surface. A NaI survey meter is operated the same way as the GM. The only difference is the NaI is used for gamma radiation (e.g. ^{125}I).

Laboratory personnel handling radioactive material should check hands frequently for contamination with a GM meter or NaI scintillation meter. If contamination is detected, remove gloves and resurvey hands. If contamination is detected on the skin, call VEHS immediately. Before lab personnel leave an area where radioactive material is used, use a GM or NaI for radioiodine to check hands, clothing, and feet for contamination. Also, lab personnel should check hands, clothes, and feet at the end of each day that radioactive material is used.

Any area that has an elevated radiation exposure reading with a GM or NaI survey meter should have a wipe test performed. If the contamination is removable, then decontaminate the area. If the area cannot be decontaminated or assistance is required, call VEHS. If the exposure readings are high near a radioactive material storage area, try rearranging the containers of radioactive material to lower the exposure rates.

Vanderbilt's Meter Calibration Policy

Radiation survey meters are required to be calibrated annually or after repairs. A meter should be checked when there is cause for concern in the meter's performance or when a contaminated probe is suspected. VEHS cannot repair meters but can sometimes diagnose common problems and suggest corrective actions.

VEHS is required to be notified when a new survey meter is acquired so that it can be included in the calibration schedule.

The PI is responsible for making arrangements to have their survey meters calibrated. VEHS offers a meter calibration service for a fee. In order to have a survey meter calibrated contact VEHS at 2-2057 to schedule a time to have the survey meter calibrated. VEHS will pick the survey meter up from the lab for calibration and leave a loaner survey meter with the lab until the lab's survey meter has been calibrated and returned. Survey meters that cannot be calibrated to +/- 20% may need to be returned to the manufacturer for repair.

Vanderbilt's Portable Radiation Meter Policy

The Radiation Safety Committee has established the following portable survey meter requirements for operations involving radiation sources. The RSC may waive some requirements of this policy if it can be demonstrated that safety would not be significantly compromised. The RSC may require that a meter be obtained when this policy does not specifically require one. The Committee may also require specific types of meters or detectors, such as scintillation detectors for ^{125}I or ion chambers for mixed gamma/x-ray radiation fields.

1. PI's with authorized possession limits that correspond to a total of 150 or more ALI's for any combination of radionuclides are required to have appropriate radiation survey meter(s) located in each laboratory room classified as a "medium hazard". The meter must be physically present at all times in these rooms.
2. PI's with authorized possession limits that correspond to a total of 5 or more ALI's for any combination of radionuclides must have immediate access to appropriate radiation survey meters. This access can be accomplished by:
 - a. Purchasing one's own meter.
 - b. Labs can share a meter if it is immediately accessible to all labs involved. A meter is considered immediately accessible if it can be retrieved within 5 minutes any time radioactive materials are being used. Meters located in another building, on a different floor of the same building, or several corridors away are not considered immediately accessible. A meter cannot be shared if it belongs to a laboratory classified as a "medium hazard" laboratory.

If a meter is shared, a signed statement from the PI who owns the meter must be submitted with the application to use radioactive materials.

3. PI's with authorized possession limits corresponding to less than 5 ALI's must also perform surveys for radioactive contamination and therefore should have reasonable access to survey meters.
4. Anyone who uses radiation-producing machines may be required by the RSC to have an appropriate survey meter.

Guidelines for Selecting Portable Radiation Survey Meters

All meters will not detect all radionuclides. The following guidelines are designed to assist in selecting meters that are appropriate for detecting various types of radiation:

1. For detecting beta emitters with a maximum beta energy greater than or equal to 150 keV such as ^{14}C , ^{35}S , or ^{32}P either of the following are recommended:
 - a. A Geiger-Mueller (GM) detector with a maximum window thickness of 1.7 mg/cm². Pancake style GM's are recommended over thin end window GM's because pancake style GM's are generally more efficient for low energy beta emitters (^{14}C or ^{35}S) and the pancake's larger window surface area makes it easier to monitor large areas for contamination.
 - b. A beta scintillator with a plastic scintillation detector. The cost of a GM is significantly lower than a beta scintillator, but the scintillator is generally more efficient.

Note: A side window GM will not be approved for use as a detector for beta emitting radionuclides, since this type of probe will not detect ^{14}C or ^{35}S and is significantly less efficient than either thin window or pancake GM's.

2. For surveying radiation sources that generate x- or gamma rays with energy greater than 30 keV, a GM pancake, GM thin end window, or a GM side window is usually adequate. As mentioned above, the pancake style is preferable since it has a larger window surface area that assists in monitoring large areas for contamination. However, solid detectors (i.e. NaI) are usually much more efficient and may be more appropriate if very low levels of radiation need to be detected.
3. For PI's approved for ^{125}I or other radiation sources that generate x- or gamma rays with energies less than 30 keV, a low energy 1" x 1 mm NaI(Tl) gamma scintillation detector is recommended.
4. For PI's approved for both beta and low energy gamma emitters (i.e. less than 30 keV), one of the following should be purchased: (1) two meters (one with a GM probe and one with a NaI probe), (2) two probes for one meter (a GM probe and a NaI probe), or (3) a beta-gamma sandwich scintillation detector. The beta-gamma scintillation detector is a combination of two scintillation probes previously described.

5. Ion chambers are used to detect x- and gamma radiation fields. They have an energy independent response and are therefore recommended for any dose rate measurements that are made to demonstrate compliance with Vanderbilt's license and/or State regulations. Ion chambers are not practical for the detection of contamination.

Probes that are separate from the body of the meter are preferable. Built-in probes are often difficult to repair or replace without sending them back to the manufacturer. Separate probes can usually be readily replaced or repaired.

Be wary of purchasing a meter if a vendor cannot or will not provide the above information. If necessary, VEHS can provide vendor information.

3. Wipes Survey– testing surfaces by wiping

Wipes should be taken for all areas that have an increased exposure reading with the GM and/or the NaI scintillation meter. Wipes are taken to determine if the contamination is removable. Wipes should also be taken on the work bench, floor, refrigerator handles, light switch, trash can lids, fume hood sill, fume hood sash, bottom of fume hood, etc. Wipe surveys should not always include exactly the same locations. Filter paper, Q-tips, or alcohol prep pads can be used for wipes, or wipes can be purchased from a vendor. A wipe should cover an area of at least 100 cm² and should not exceed 300 cm².

The wipes should be counted on a liquid scintillation counter (LSC) and/or a gamma counter depending on the radionuclide(s) used. If only beta emitting (i.e. ³H, ¹⁴C, or ³²P) radionuclides are used, the wipes should be counted on a LSC. If only gamma emitting radionuclide(s) (i.e. ⁵¹Cr) are used the wipes can be counted on a gamma counter.

Vanderbilt's Radiation Survey Policy

Radiation workers are responsible for conducting surveys of their work areas to (a) assure that radiation sources are adequately shielded and (b) to check for radioactive contamination. If gamma or high energy beta sources are used, radiation meter surveys should be made to check radiation levels in all work areas, storage areas, around waste containers, and in nearby uncontrolled areas. Contamination checks are made by using an appropriate survey meter to scan suspect surfaces or by wipe testing surfaces, i.e. rubbing a piece of paper or cotton-tipped applicator over the surface and then counting it for radioactivity with a suitable counter.

Radiation workers are personally responsible for checking themselves for contamination before leaving radioactive material areas.

A simple survey log is recommended to help the radiation worker maintain an awareness of changes in radiation levels that may indicate a need for a change in procedure.

Documented weekly surveys are required if a laboratory is classified as a “Medium Hazard” lab. If these surveys are not performed it will be necessary to downgrade the lab classification to “Low Hazard” by decreasing the PI’s radioactive material possession limit.

Periodic inspections and surveys are performed by VEHS at a frequency commensurate with the hazard rating of the laboratory.

F. Facilities and Equipment

1. Work Surfaces

Work surfaces should be constructed of non-porous materials and covered with absorbent paper that has a plastic backing. The absorbent paper should be replaced at frequent intervals.

2. Fume Hoods

Procedures involving aerosols, dusts, or gaseous products that might produce airborne contamination shall be conducted in a hood or glove box. Requirements to use a fume hood when working with radioactive materials are given in Table 5. The average airflow at the face of the hood must be at least 0.5 m/sec (100 linear feet per minute). Hood exhaust fans must be “on” whenever the hood is in use.

Table 5: Fume Hood Requirements for Radioactive Material

	Number of ALI’s* Used	Hood Requirement
Volatile Radioisotopes	< 1	No Hood Required
	1 – 10	Standard Chemical Fume Hood
	> 10	Activated Charcoal Filter** Required
Volatile Radioiodines	<1	Standard Chemical Fume Hood
	>1	Activated Charcoal Filter** Required
Non-Volatile Radioisotopes	< 10	No Hood Required
	10 – 100	Standard Chemical Fume Hood
	> 100	HEPA Filter*** Required

*ALI or Annual Limit of Intake. A list of ALI’s can be found in Appendix B “Table of Radionuclides

**Activated charcoal filter for gaseous contamination

***High Efficiency Particulate Air (HEPA) filter for particulate airborne contamination

Releases to the atmosphere shall not exceed the maximum permissible concentrations in air specified in State regulations. Traps or filters may be required to ensure that environmental releases are within acceptable limits. Should either activated charcoal filter or a HEPA filter need to be used, the filters must be incorporated into the fume hood system. As an alternative to installing a filter in an existing hood, a tabletop hood equipped with one of these filters can be placed inside of an existing fume hood.

3. Radioactive Material Storage Areas

Radioactive materials must be stored and shielded to maintain radiation exposure to laboratory personnel As Low As Reasonably Achievable (ALARA). If possible, radioactive materials should be stored separately from non-radioactive material. The storage area must be clearly marked with appropriate warning signs and the radioactive material must be secured from unauthorized access or removal. Radioactive material should be returned to the storage location immediately after use. Sufficient shielding to reduce radiation levels to 2 mrem/hr (0.02 mSv) at 30 cm from the storage area. All storage areas must be secured against unauthorized access and removal of radioactive material.

4. Location of Radioactive Material Work Areas

Radioactive materials work should be confined to only the area necessary. It is desirable to have one area designated as a “hot” work area for high activities and other areas designated as “low level” work areas. The PI should consider the effects of a possible spill, accident, and security when choosing the designated work areas. Work areas must utilize sufficient shielding to minimize radiation exposure to personnel.

5. Classification of Radioactive Material Laboratories

Radioactive material labs are classified on the basis of the radionuclides and the corresponding possession limits that are approved for the PI. The toxicity of radioactive material varies considerably so it is necessary to “normalize” the approved activities for the various radionuclides. This is done by determining the number of ALIs (Annual Limit on Intake) represented by each radionuclide possession limit. Labs are then classified according to the following:

<u>Lab Hazard Rating</u>	<u>Approved No. of ALIs</u>
Slight	1
Low	1-150
Medium	150-100,000
High	>100,000

The approved number of ALIs is the sum of all radionuclides for which the PI is approved. If a PI has more than one laboratory room, at least one of the rooms will be rated at the calculated level. Other rooms may be rated at a lower level.

Example: A PI is approved for:

^3H 20 mCi (740 MBq)	ALI = 80.0 mCi (2,960 MBq)	# ALIs = 0.25
^{125}I 10 mCi (370 MBq)	ALI = 0.04 mCi (1.48 MBq)	# ALIs = 250.00
^{32}P 15 mCi (555 MBq)	ALI = 0.40 mCi (14.8 MBq)	# ALIs = 37.5

Total number of ALIs = 287.75, so the major lab classification = Medium

G. Survey Instrument Requirements

Laboratories classified as Medium or High hazard labs must have a portable survey meter that is appropriate for the type of radiation being used. Laboratories with a Low rating must have ready access to a survey instrument. Labs only using ^3H or ^{63}Ni are exempt from this requirement.

Survey instruments are required to be calibrated annually or after repairs are made to the instrument. The PI is responsible for making arrangements for having survey equipment calibrated. VEHS provides a calibration service for a fee.

H. Radiation Safety Training Requirements

Prior to handling radioactive material at Vanderbilt, each person must satisfy the following training requirements:

1. Specific Training Requirement

All radiation workers shall be instructed in safe handling methods for radioactive material and radiation safety principals. The PI shall instruct employees in procedures applicable to the specific operation employed in the laboratory including on-the-job training.

2. Course Requirement: Radiation Safety Principals

Principal Investigators are responsible for assuring that their radiation workers have received adequate instruction in radiation safety principals. The three alternatives to satisfy this requirement are given below:

- a. Attend the Radiation Safety Principals course given by VEHS
- b. Furnish evidence of previous attendance at a radiation safety course
- c. Pass an exam administered by VEHS

3. Orientation Lecture: Vanderbilt Radiation Safety Policies and Procedures

All new radiation workers, including Principal Investigators, are required to attend this lecture, regardless of prior experience or training.

4. Ongoing Training:

Principal Investigators are responsible for ensuring that all their radiation workers complete annual refresher training in radiation safety principals.

Go to the VEHS website at www.safety.vanderbilt.edu for a complete schedule of the Radiation Safety Principals classes and the Orientation lectures.

I. Animals Containing Radioactive Materials

1. Warning Signs

All cages housing animals containing radioactive materials shall be labeled with a “Caution, Radioactive Materials” label.

A “Caution, Radioactive Materials” sign must be posted on the cage. The sign must remain on the cage until the animal has been removed and the cage has been decontaminated.

2. Collections and Disposal of Radioactive Excreta

Any excreta or litter that is radioactive must be disposed in the same manner as biological radioactive waste.

3. Ventilation

Adequate ventilation must be provided for animals administered radioactive materials that may be volatilized.

J. Use of Division of Animal Care Facilities

Principal Investigators desiring to use these facilities must submit a written request to the Division of Animal Care. Use of these facilities does not relieve the investigator of the responsibilities for the use of the radioactive materials. Radioactive animals should be isolated from other animals. The investigator is responsible for changing and collecting radioactive litter and for providing all necessary monitoring. The cage must be decontaminated before being returned to Animal Care.

Radioactive animals should not be petted or groomed.

If radioactive materials are expired from the animal or are excreted in a volatile form, adequate ventilation must be provided.

Appropriate disposable gloves and a lab coat must be worn when changing litter or cleaning the cages. Any excreta or litter that is radioactive must be treated as biological waste.

All cages must be monitored for radioactive contamination after the animals are removed and decontaminated to below the criteria stated in section 4 of this manual.

All locations where radioactive animals were injected, housed, or sacrificed must be monitored for contamination. Be sure to monitor yourself after any work with radioactive animals.

Precautions should be taken to minimize dust production.

Experimental animals administered radioactive materials should not be used for human or animal consumption.

K. General Radiation Safety Enforcement Policy

For serious or flagrant radiation safety violations, the Principal Investigator's (PI) authorization to use radioactive material will be immediately suspended. Following a suspension, the PI must appear before the RSC and present an acceptable plan for corrective actions before authorization can be reinstated. For less serious violations, or a pattern that indicates an overall laxity in their radiation safety program, the PI will be given one written warning before a suspension is imposed.

Serious incidents or flagrant radiation safety violations can include, but are not limited to:

1. Activities that result in radioactive contamination in public areas
2. Radiation exposure to a member of the general public in excess of the legal limits
3. Overexposure of an individual to radiation
4. Releases of radioactive material to the environment in excess of legal limits
5. Leaving radioactive material unsecured in a public access area
6. Allowing an individual to work with radiation sources without meeting radiation safety training requirements

Violations for which a single written notice will be dispensed can include, but are not limited to:

1. Food and/or beverage in inappropriate locations
2. Failure to perform required surveys
3. Failing to provide and require the use of radiation monitoring badges when required
4. Failure to promptly decontaminate when radioactive contamination is detected

L. Radioactive Material Security

Radioactive material must be secured against unauthorized access or removal. Unattended radioactive material may be secured by the following methods:

- A. Storage of stock solutions with greater than 500 times the value listed under column #6, "Container Posting Level", in Appendix B entitled "Table of Radionuclides" must be secured by both the following methods:
 1. Stock solutions must be stored in a room that can be locked when unattended and
 2. within the room, the stock solution must be stored in an interior locked room or in a locked non-portable storage unit such as a locked refrigerator, freezer, or cabinet.

B. Radioactive material in use or storage of stock solution with less than 500 times the “Container Posting Level”:

1. The laboratory must be locked when unattended, or
2. If the material is in an unlocked lab, corridor or common equipment area that cannot be locked, then it must be in a locked non-portable storage unit, such as a locked refrigerator, freezer, or cabinet.

Note:

1. *Paragraph “A” above applies to all activities conducted under applications and amendments submitted after June 12, 2002 by a PI in which their authorized possession limit for a radionuclide exceeds 500 times the “Container Posting Level” for that radionuclide.*
2. *Paragraph “A” above does not apply to radioactive material used in areas or devices for the preparation or administration of radioactive material to humans for medical diagnosis or treatment.*

Enforcement Policy for Security of Radioactive Material

Security of radioactive material must depend on the diligence and awareness of individual users and is a reflection of the safety culture of an institution. The following action will be taken if radioactive material is observed to be unsecured in a laboratory or shared departmental facility:

1. On the first violation, the Radiation Safety Officer will immediately suspend radioactive material ordering privileges for the responsible PI(s) until receipt of a written acknowledgement of the violation and what action will be taken to assure radioactive material is secured against unauthorized removal.
2. On subsequent violations, the PI(s) ordering privileges will be immediately suspended. In order to be reinstated, the PI will be required to submit a plan to correct the security problem to the Radiation Safety Committee. The RSC will then meet to consider reinstatement.

Section 5: Receipt, Transfer, and Disposal of Radioactive Material

A. Ordering Radioactive Material

1. Radioactive material orders can only be placed by VEHS. Only a PI who has been approved by the RSC may order and/or receive radioactive material.
2. Radioactive material can be ordered online at the VEHS website www.safety.vanderbilt.edu or requisitions for radioactive material can be placed on a “Requisition to Purchase Radioactive Material”. This form can be downloaded from the VEHS website at www.safety.vanderbilt.edu. Requisitions require the PI’s signature or the signature of an individual who the PI has authorized to order radioactive material. The PI must submit in writing to VEHS the names of the individuals who are authorized to place radioactive material orders.
3. Radioactive material possession limits are established by the RSC for each PI. VEHS must verify that the receipt of an order will not cause a PI to exceed the authorized possession limit.
4. Radioactive material obtained at no charge must be processed through VEHS.
5. The PI, who orders the radioactive material, is responsible for the safe use and disposal of the material. This responsibility is not transferred to another individual who uses the radioactive material unless an official transfer has been effected through VEHS.

License Exempt Purchases

1. Quantities of radioactive material that do not exceed the Container Posting Levels specified in Appendix B “Table of Radionuclides” can sometimes be purchased as “license exempt”. The purchase must be from a commercial vendor holding a special license authorizing exempt purchases. Radioactive material accountability records are not required for these purchases, nor are they included in the PI’s radioactive material inventory.
2. Any PI who has been authorized by the RSC to use specific radionuclides may purchase those radionuclides as license exempt.
3. License-exempt purchases must be ordered in the same manner as non-exempt radioactive material. An accountability record will not be issued for an exempt radiation source.
4. Materials received as licensed exempt cannot be administered to humans.

B. Receipt of Radioactive Material Packages

1. All radioactive material must be received by VEHS.
2. VEHS receives, surveys, inventories, and delivers radioactive material directly to the laboratory.
3. VEHS will only release radioactive material to trained radiation workers.

4. If the PI is not authorized for the type or the amount of radioactive material, then VEHS will hold the radioactive material until the problem is resolved.

C. Receipt and Disposal Records

1. The PI is required to maintain receipt and disposal records for all radioactive material. An accountability record is issued to the PI when the order is delivered to the laboratory.
2. After the radioactive material has been disposed the accountability record is to be returned to VEHS. VEHS maintains a file of these records for inspection by regulatory agencies.
3. VEHS maintains centralized radioactive material inventory records for Vanderbilt.

D. Transfer of Radioactive Material

VEHS must approve all transfer requests before the transfer is made. VEHS must verify that the PI in question is authorized to receive the radionuclide and will not exceed authorized limits.

Transfer Procedure

1. Complete the top section of the *Radioisotope Record Internal Transfer Form* except for the *VEHS Use Only* and the *New Requisition Number* sections. This form is available from the VEHS office and can also be downloaded from the VEHS web site www.safety.vanderbilt.edu.
2. Fax the form to the VEHS Radioisotope Order Office at 3-2041.
3. If the transfer is approved, the form will be returned to the *P.I. transferring from*. Then the *PI transferring to* may be given the radioactive material along with the **Internal Transfer Form**. The lower half of the form is to be used as the disposal sheet. It does not have to be on pink colored paper.
4. The *P.I. transferring from* must also record this transfer on the original requisition disposal record.

Additional Procedures:

1. Contact VEHS if you want to transport radioactive material to an off site location.
2. Transfers to the VA Medical Center must receive the prior approval of the VA Radiation Safety Officer. The radioactive material should not be transported on a public street.

E. Shipping Radioactive Material

Contact VEHS (2-2057) to make arrangements to ship radioactive material.

F. Radioactive Waste Disposal

See Appendix C "Radioactive Waste Disposal"

Section 6: Emergency Procedures

For Assistance Contact

Vanderbilt Environmental Health and Safety

322-2057

(After normal working hours, call the Vanderbilt Operator or VEHS pager # 835-4965)

A. Introduction

Emergencies range from minor spills of radioactivity, involving relatively no personal hazard, to major radiation incidents involving extreme hazards. Because of the wide range and variety of hazards and the numerous possible complicating factors, set rules of emergency procedures cannot be made to cover all possible situations. In any emergency, however, the primary concern must always be the protection of personnel from radiation hazards. If radioactive contamination is involved, all persons who were in the area at the time of the incident shall be assembled and monitored for contamination. The secondary concern is confinement of contamination to the local area of the accident.

B. Clean up of Radioactive Contamination

1. Principal Investigators are responsible for providing personnel to clean up any contamination that results from work conducted under their authorization.
2. VEHS will monitor and supervise clean up of all major spills.
3. Housekeeping personnel shall not be allowed to clean up of radioactive contamination.

C. Notification Requirements

The following incidents must be reported to VEHS immediately after their occurrence:

1. Any major spill of radioactive material.
2. Contamination of personnel.
3. Accidental human intake of radioactive material.
4. Exposure of individuals to excessive levels of radiation.
5. Theft or loss of radioactive material.
6. Large releases of radioactive material into the air or water.

D. Exposures Exceeding the Maximum Permissible Dose

Individuals suspected to have been overexposed will be suspended from further work with radiation sources pending the outcome of an investigation by VEHS.

E. Radiation Emergency Procedures

State regulations require that radiation emergency procedures be posted in areas where radioactive material is used or stored. Vanderbilt's radiation emergency procedures can be found in Appendix D "Radiation Emergency Procedures".

Section 7: Responsibilities and Rules for Radiotherapy Treatments

A. Brachytherapy

1. Radiation Oncology Responsibilities

- a. Insertion and removal of sealed sources in patients shall only be performed by physicians specifically authorized by the RSC or by physicians operating under their direct supervision.
- b. All patients with temporary implants must be hospitalized in a private room approved by the RSC.

Patients with permanently implanted sources must be hospitalized in a private room approved by the RSC. VEHS or Radiation Oncology will evaluate each case to determine if the patient may be discharged without restriction or treated as an outpatient.

Application must be made to the RSC for authorization to use hospital rooms for brachytherapy patients, on a form 7A available on the VEHS web site www.safety.vanderbilt.edu . VEHS maintains a list of rooms authorized for use with brachytherapy patients.

- c. Visitors, nursing staff, and others must observe radiation precautions, when the patient's room is posted with a radiation warning sign. These precautions are given in part C of this section. Precautions are also summarized on the posted patient warning signs.
- d. Exposure rates in unrestricted areas (hallway and adjacent patient rooms) must not exceed 2 mrem (0.02 mSv) in any one hour or 100 mrem (1 mSv) in a year. This may require the use of bedside lead shields in some cases or having adjacent rooms vacated while radiation sources are present.
- e. A radiotherapy patient warning sign must be posted on the door of the patient's room when radiation precautions are required. If isolation rooms are used, the ante room door must also be posted if the exposure rate exceeds 2mrem/hour (0.02 mSv/hour) in the ante room. State regulations require that the number of sources used, the activity, date, and radiation level at one meter be recorded on this sign. The radiation level may be determined by measurement with a survey meter or by calculation.

Relatively high exposure rates may be expected from ^{137}Cs , or ^{192}Ir patients. Before sources have been loaded in the patient, VEHS must be notified so they may make the required measurements and post the warning sign.

Radiation levels are much lower for ^{125}I patients. Radiation Oncology is responsible for the survey and posting requirements for these patients.

- f. During hospitalization, radiation precautions must be observed until VEHS removes the radiation warning sign. ^{125}I patients may be released from the hospital if the shielded exposure rate at one meter is less than 0.2 mR/hour, as determined by VEHS measurements.

Prior to release of the patient and the room, VEHS staff will measure the radiation exposure rate of the patient and make a final survey of the patient's room to check for lost sources. Removal of the warning sign from the patient's door signifies that the room has been cleared for unrestricted occupancy.

- g. When radiation sources are implanted in surgery, it is the responsibility of the radiation oncologist to instruct other participating personnel in radiation precautions.
- h. Radiation exposure to other patients in the recovery room must not exceed 2mrem (0.02 mSv) in any hour or 100 mrem (1 mSv) to an individual in a year. Recovery room personnel must be notified sufficiently in advance to make arrangements for the patients.
- i. An accountability log tracking use from storage to return to storage of all sealed sources must be maintained for inspection by the Tennessee Division of Radiological Health. The record shall include the following information:
 - 1. date and number of sealed sources removed from storage, and quantity of material in each sealed source
 - 2. location of use or patient name
 - 3. date of return, and indication that all sources are accounted for
 - 4. signature of individual removing or returning sources.
- j. All persons who regularly handle brachytherapy sources must wear whole body and ring dosimeters. The user must make full use of protective devices such as remote handling tools, L-blocks, etc.
- k. Transport of brachytherapy sources shall be in adequately shielded containers. Shielded containers should be left on the floor (usually in the patient's room) for use in event of an emergency. Return all unused sources to the storage room immediately after the implant procedure is completed.

2. VEHS Responsibilities

- a. After a patient has been loaded with ^{137}Cs or ^{192}Ir , VEHS will post radiation warning signs and measure radiation levels from the patient and in adjacent unrestricted areas.

When radiation sources are implanted in surgery, VEHS must assure that no radiation sources remain in the room after surgery. Sources of very small dimensions such as ^{125}I seeds are very difficult to locate without a survey meter. Therefore, it is the responsibility of VEHS to perform a radiation survey when this type of source is implanted.

- b. VEHS will perform the closing survey in the patient's room to verify that no sources remain after ^{125}I sources have been implanted. VEHS will also make measurements of

all patients released from the hospital that contain radioactive implants to verify that radiation exposure rates are within required limits.

- c. VEHS will maintain the list of hospital rooms approved by the RSC for use with brachytherapy patients.
- d. Records of the surveys made for each patient will be collected by VEHS and maintained for inspection by regulatory limits.
- e. VEHS will test all sealed sources for contamination at intervals not to exceed six months.
- f. VEHS will conduct a physical inventory of all sealed sources at quarterly intervals.
- g. VEHS will be available for radiation emergencies.
- h. VEHS must conduct a source count and a radiation survey of the patient to confirm that no sources remain. This must be documented on the back of the door sign.

B. Therapeutic Quantities of Radiopharmaceuticals

1. Nuclear Medicine Responsibilities

- a. Radiopharmaceuticals for therapeutic purposes shall be administered by, or under the supervision of, physicians authorized by the RSC.
- b. The radiation precautions given below must be followed whenever a hospitalized patient does not meet release criteria. Once a patient falls below the release criteria, the radiation precautions are no longer required.
- c. Inpatient admitting must be notified when a patient is to receive therapeutic quantities of radioactive material. The patient must be assigned to a room approved for this purpose by the RSC. The nursing staff must be informed whenever radiation precautions are required for a patient.
- d. Prior to the administration of therapeutic quantities of ^{131}I , the room must be prepared to avoid subsequent contamination problems. The floor, bathroom and major surfaces in the room that are likely to become contaminated must be covered with protective material, as appropriate to the amounts of contamination expected.
- e. If a patient will be administered therapeutic quantities of a radiopharmaceutical, notify VEHS of the time and location of the administration so they may post required signs and make radiation measurements. Exposure rates in unrestricted areas (hallway and adjacent patient rooms) must not exceed 2 mrem (0.02 mSv) in any one hour or 100 mrem (1 mSv) to an individual in one year.
- f. Whenever possible, large therapeutic doses should be administered in the patient's room.

- g. Patient care instructions, nursing procedures and visitor restrictions are given in part C of this section and are also summarized on the warning sign posted on the patient's door.
- h. Radioactive tissue specimens, blood, ascetic fluid, excreta, or cadavers may be delivered to laboratory pathology services. All specimens from these patients that are sent to a laboratory must be labeled "Radioactive". If possible, specimens should be taken before administration of radioactive material.
- i. The patient may be released from the hospital when the administered radioactivity falls the release criteria. If the patient remains hospitalized, the radiation precautions may not be removed until the patient meets release criteria. VEHS will be responsible for determining when the activity in a patient has reached these levels.
- j. When a patient containing residual activity leaves the hospital, the physician is responsible for providing any necessary instructions to the patient and family concerning the nature and hazard of the treatment and any further precautions that may be necessary.
- k. Upon discharge of the patient or removal of the radiation precautions, the room and contents must be surveyed to ensure that radiation and contamination levels must meet requirements for unrestricted use. VEHS will decontaminate the room and will maintain monitoring records.

2. VEHS Responsibilities

- a. Radiation warning signs must be posted whenever the administered activity exceeds release criteria. These signs will be posted and removed by VEHS.
- b. After the administration of radiopharmaceuticals, VEHS will perform the radiation surveys required by State regulations.
- c. VEHS will determine when a patient may be released from the hospital or radiation precautions may be removed.
- d. Bags of radioactive waste generated by radiotherapy patients will be collected and disposed by VEHS.
- e. Before a therapy patient's room can be reassigned to another patient, the room must be surveyed for contamination. When surveys indicate that no contamination exists above allowable limits, the room warning sign will be removed. Removal of this sign signifies that another patient may occupy the room.
- f. VEHS will maintain all survey records for inspection by the State regulatory agency.
- g. VEHS is available for routine consultation and for any emergency situation. The VEHS telephone number is listed on the radiation warning sign.

C. General Staff and Visitor Precautions

1. Patients who have received a tracer dose of radioactive materials for diagnostic tests or who have received small amounts for minor therapies present no special hazard. However, patients containing appreciable therapeutic quantities of radioactive materials may constitute a significant radiation source. Guidelines designed to maintain radiation exposure at safe levels have been established for dealing with these patients. Patients must usually be in a private room. A radiation warning sign posted on the room door can identify these patients.
2. Hazards from radioactive materials arise from:
 - a. Radiation emitted by radioactive materials located external to your body, such as the radioactivity in the patient's body.
 - b. Contamination of skin with radioactive materials. This could occur, for example, when handling radioactive excreta from the patient.
 - c. Inhalation or ingestion of radioactive materials.

For unsealed sources (radioiodine, or radioactive phosphorus) all three hazard types usually exist.

For sealed sources (cesium, iridium seeds, or ^{125}I seeds) there is no possibility of contamination, inhalation or ingestion of radioactive material, provided these sources are not damaged, but there is an external radiation hazard. VEHS tests these sources for leakage on a regular basis to assure that they are safe.

3. The attitude of the attendant toward the patient is important. Good nursing care involves relieving anxiety, and since many people have a fear of radiation, the attitude of the hospital personnel can do much to temper this fear. Nurses should not act as if they are afraid of the patient or have any anxiety about being in the patient's room. There is no reason to be more concerned about caring for a patient containing radioactive material than for a patient with an infectious disease.
4. Radiation precautions will be in effect during the entire period that the radiation warning signs are posted. Removal of the signs signifies that the radiation precautions are no longer necessary.
5. If there are any special instructions for a particular patient they will be noted on the patient's chart or on the posted signs.
6. Always provide adequate care for the patient but work efficiently and quickly. Patients should be encouraged to care for themselves and to be as self-sufficient as possible, thus reducing the need for contact with hospital personnel.
7. Pregnant staff should not be responsible for the routine care of radiotherapy patients.

8. VEHS will perform surveys of the therapy patient's room, remove all radioactive waste, and will be available to answer questions concerning the hazards or the precautions needed for a particular procedure.

9. Release of the room for another patient:

For temporary implants, VEHS will verify that no sources have been left in the room and will remove the sign from the patient's door.

For radioiodine therapies, VEHS will survey the room before it is reassigned to another patient. VEHS will remove the warning signs at this time to signify that the room is ready for the next patient.

10. Radiation monitoring badges will be issued to nurses administering care to therapy patients.

D. Radiation Precautions regarding Patients receiving Temporary Implants

1. The radioactive material is contained in metal tubes, needles or ribbons and is inserted into a body cavity (vagina, nasopharynx) or directly into tissue. The material is not dispersed within the patient's body and fluid excreted from the patient is not radioactive. These sources are temporary implants and no residual radiation remains in the room or patient after removal of the sources.

The tubes or needles emit gamma radiation and the exposure rates encountered are considerable a few feet from the patient. Hence all individuals should maintain as much distance as possible from the patient.

The restrictions given below are to remain in effect until the sources are removed.

2. Temporary brachytherapy implant patients must be confined to a private room. The patient must remain in bed unless orders to the contrary are written.

3. Visitors should stay at least 6 feet from the patient and should limit their visit to one hour per day. There should be no visitors who are pregnant or under age 18.

4. Nursing and other hospital staff should minimize time spent in the room and near the patient, consistent with the provision of all necessary care. No special precautions are needed for vomit, urine, eating utensils, etc.

Bed baths given by a nurse should be omitted while the sources are in place. Personal care should not be given gynecological patients during the treatment period. The perineal pad may be changed when necessary unless orders to the contrary have been given.

Only the attending physician or radiation oncologist may change any dressings or bandages used to cover an area of insertion.

All linens, gowns, dressings, equipment and trash containers must remain in the room until Radiation Oncology and VEHS have accounted for all sources and the release the room.

Nurses who are pregnant should not be assigned to these patients.

5. If the implanted source becomes loose or separated from the patient, or if the patient requires emergency surgery, contact the attending Radiation Oncologist immediately. Never touch needles, capsules or applicators containing radium or cesium. If a source becomes dislodged, use long forceps and put it in the shielded cart or the corner of the room.
6. At the conclusion of the treatment VEHS will verify that no sources remain in either the patient or the room. After verification, the radiation warning sign is to be removed. Removal of the sign signifies that the room is available for occupancy for the next patient.

E. Radiation Precautions regarding Patients receiving Permanent Implants

1. Radioactive material in tiny containers is inserted into tumors and left there permanently, ultimately becoming inactive through radioactive decay. The radioactive material is contained within metallic seeds and is not dispersed within the patient's body. Fluids excreted from the patient are not radioactive. No special precautions are needed for urine or vomit.

VEHS will measure the radiation levels emitted by each patient. The radiation precautions given below may be removed after a specific length of time since the radiation levels are continually decreasing due to radioactive decay. The date at which these precautions can be removed will be given on the caution sign placed on the patient's door. In some cases, radiation precautions may not be required at all due to the very low amounts of radioactivity used.

2. Patients should remain in their private rooms until the date at which the radiation precautions are removed.
3. Visiting time is normally restricted to one hour per day, and visitors should stay at least 6 feet from the patient. There should be no visitors who are pregnant or under age 18.
4. Nursing and other hospital staff should minimize time spent in the room and near the patient, consistent with the provision of all necessary care. Bed baths given by a nurse should be omitted while radiation precautions are in effect.

Any dressing or bandages used to cover an area of insertion may be changed only by the attending physician or radiation oncologist.

All linens, gowns, dressings, equipment and trash containers must remain in the room until VEHS has accounted for all sources and the release the room.

Pregnant nurses should not be assigned to these patients.

5. Call Radiation Oncology should you locate any loose metallic seeds in the patient's room. Do not handle seeds with bare hands. If a source becomes dislodged, use long forceps and put it in the shielded cart or the corner of the room.

6. At the conclusion of the treatment, VEHS will verify that no sources remain in the room. After verification, the radiation warning sign will be removed. Removal of the sign signifies that the room is available for occupancy by the next patient.

F. Radiation Precautions regarding Patients receiving Radioiodine

1. The radioactive iodine (^{131}I) is administered orally to the patient. The iodine concentrates in the patient's thyroid. However, most of it will be eliminated from the patient via the urine within the first 48 hours. Radioiodine will also be present in perspiration and other body excreta. Radioactivity remaining in the body after 48 hours is located primarily in the patient's thyroid and is eliminated slowly.

Fluids from the patient's body will contaminate linen, bed clothes, and practically anything the patient touches. Thus, the patient and room should be handled as one would handle a surgical procedure (for example, a gown, shoe covers, and gloves must be worn).

The primary hazard to attending personnel is the possible intake of radioactive material that has been released from the patient's body. Major routes of potential intake are passage through skin and ingestion. For example, if you were to touch a surface contaminated with radioactivity, your fingers could transfer radioactivity to your mouth when eating, smoking, or applying cosmetics.

A secondary hazard is the radiation emitted by the patient's body or from collections of urine. Personnel should minimize time spent in the vicinity of these sources and maintain as much distance as possible while delivering the required medical care.

2. Patients receiving the ^{131}I therapy must be assigned to a room with a toilet. The floor and any objects the patient is likely to touch must be covered with plastic or other protective material to prevent contamination. The Paint Shop will prepare the room prior to the administration of the radioiodine. A strict isolation setup needs to be ordered for the patient. In addition, shoe covers and a waterproof mattress cover should be ordered.
3. The patients will receive the following instructions:
 - a. You are restricted to your room.
 - b. You must use disposable eating utensils. These utensils should be placed in the special waste container after use.
 - c. You should wear gloves when handling items that are not protected by coverings, such as personal items the patient may wish to take home.
 - d. You should flush the toilet two or three times after each use. This will insure that all radioactive urine is washed from the toilet bowl.
 - e. You should avoid physical contact with visitors.

4. Visitors have the following restrictions:

- a. Visits should be limited to 1 hour per day. No pregnant women or persons under age 18 should visit the patient without special permission from VEHS.
- b. Visitors should remain at least 6 feet from the patient.
- c. Visitors must be protected with gowns, shoe covers, and gloves. Visitors should not handle any items in the room.
- d. Visitors must not smoke, eat, or drink while in the patient's room.

5. Nursing Care

- a. Nursing and other hospital staff should minimize time spent in the room and near the patient, consistent with the provision of all necessary care.
- b. Attending personnel must wear disposable gloves when handling or touching anything in the room. Remove gloves and place in designated waste container before leaving the room.
- c. Gowns should be worn if significant time will be spent in the room or whenever necessary to protect your clothes from contact with the patient or items in the room.
- d. Shoe covers should be worn when in the patient's room. They must be removed when leaving the room to avoid tracking contamination from the room.
- e. Use special caution when encountering vomit within the first 24 hours, or spills of urine or urinary incontinence within the first 48 hours. Call VEHS if this occurs.
- f. Disposable items such as plates and eating utensils should be used whenever possible. These items must be placed in the designated waste container.
- g. Bedclothes, towels, and bed linen used by the patient should be placed in the laundry bag provided and left in the patient's room until monitored by VEHS. If contaminated, they will be collected and later released when they are no longer radioactive.
- h. All items within the room should be checked for contamination by VEHS staff before being removed.
- i. Excess food may be flushed down the toilet.
- j. Nursing staff should not provide assistance in bathing the patient for the first 48 hours unless specifically approved by the physician. However, the patient should be encouraged to bathe daily.
- k. All specimens of tissue, blood, ascetic fluid, or excreta from radioiodine patients must be labeled as "Radioactive" before delivery to a clinical laboratory.

6. Before the patient's room can be reassigned to another patient, VEHS must survey the room for contamination and remove all radioactive waste. The room will be decontaminated if necessary.

G. Radiation Precautions regarding Patients receiving Radioactive Phosphorus

1. General Principals

- a. Radioactive phosphorus (^{32}P) may be injected into the pleural or peritoneal space for treatment of malignant effusions. Since the radioactive material remains in these cavities no special precautions are necessary for the patient's urine, vomit, etc. Care must be taken, however, if there is leakage from the puncture wound.
- b. ^{32}P may also be given orally or intravenously for treatment of polycythemia vera, leukemia, or bone metastases.
- c. Special radiation precautions are not required for patients administered ^{32}P .
- d. There is no external radiation emitted from these patients. Patients are allowed visitors in accordance with the usual hospital rules.
- e. Patient must have private room. However, patient may be allowed to leave room for medical care, visiting, etc.

2. Intracavity Injections – Nursing Care

- a. Surgical dressings over the incision may be changed only as directed by a physician. If at any time the dressing becomes damp, stained, or bloody, the physician in charge shall be notified. Contaminated dressings should be placed in a plastic bag and held for disposal by VEHS. If there is no drainage from the wound after the first few days, dressings may be handled in the usual manner.
- b. Gloves should be worn when cleaning any area around the incision or when handling contaminated dressings.
- c. Bedding may be changed unless there has been drainage from the puncture wound, in which case VEHS should be notified.

3. Oral Administration or Intravenous Injection – Nursing Care

- a. During the first 24 hours, care should be exercised when handling urine. Gloves should be worn and any spilled urine should be wiped up with paper towels, placed in a plastic bag, and held for disposal by VEHS.
- b. If the ^{32}P has been administered orally, care must also be exercised when handling any vomit that occurs within 24 hours. Handle in the same manner as urine.

H. Patients receiving small doses of radioactive material for diagnostic studies or minor therapies

1. General Principals

- a. The most commonly used radioactive material in Nuclear Medicine studies is technetium-99m (^{99m}Tc), a gamma emitter with a half-life of 6 hours. In many of the studies, especially bone and renal studies, the radioactive compounds are removed from the body in the urine and occasionally in the stool. Most of the radioactivity is gone after 24 hours.
- b. The objective in diagnostic procedures involving radionuclides is to determine something about an organ's shape or function. The administered dose must be small so as not to produce any radiation effect, which might result in a change in the status quo of the patient.
- c. With minor therapies, such as radioiodine for treatment of hyperthyroidism, the amount of radioactivity administered is sufficiently small to permit outpatient treatment of these patients.
- d. Relatively little radiation exposure or contamination hazard is associated with patients receiving radionuclides for minor therapies or diagnostic studies. Radiation warning signs are not posted for these patients.

2. Patient/Visitor Restrictions

There are no restrictions on the patient's activities or contacts with other patients or visitors, unless otherwise advised by the physician or VEHS.

3. Nursing Care

No special precautions are required when working with these patients, except during the first 24 hours when normal hygienic precautions (such as wearing gloves) should be followed when handling bodily fluids. Nursing personnel are not required to wear radiation monitoring badges. No special precautions are needed for dishes, instruments, or linen. Reducing time spent at bedside during the first 24 hours will minimize external radiation.

I. VEHS Responsibilities during patient procedures involving radioactive material

1. Brachytherapies

a. Temporary Implants:

VEHS will post radiation warning signs and measure radiation levels when notified on implants occurring during normal working hours.

b. Permanent Implants:

1. VEHS will post warning signs and make the required radiation measurements, and instruct nursing personnel as necessary.

2. VEHS will determine the date when radiation precautions may be removed.
 3. Upon removal of radiation precautions, VEHS will perform a final survey and remove warning signs.
 - c. VEHS will provide monitoring assistance in surgery when requested or deemed necessary.
 - d. Records of the surveys made for each patient will be collected by VEHS and maintained for inspection by the Tennessee Division of Radiological Health.
 - e. VEHS will test all sealed sources for contamination at intervals not to exceed every six months.
 - f. VEHS will conduct a physical inventory of all sealed sources at quarterly intervals.
 - g. VEHS will be available for any emergency situation.
2. Radiopharmaceutical Therapies
- a. Radiation warning signs must be posted whenever the administered activity exceeds the release criteria. These signs will be posted and removed by VEHS.
 - b. After administration of the radiopharmaceuticals, VEHS will perform the radiation surveys required by State regulations.
 - c. VEHS will determine when a patient may be released from the hospital or radiation precautions may be removed. The Nuclear Medicine physician can also determine when to release the patient, based on professional judgment.
 - d. Bags of radioactive waste generated by radiotherapy patients will be collected and disposed by VEHS. Odorous waste will normally be collected on a daily basis.
 - e. Before a therapy patient's room can be assigned to another patient, the room must be surveyed for contamination. VEHS will decontaminate the room. When surveys indicate that no contamination exists above allowable limits, the room warning sign will be removed. Removal of this sign signifies that another patient may occupy the room.
 - f. Records of all surveys will be maintained for inspection by the State regulatory agency.
 - g. The VEHS phone number listed on the radiation warning sign, is available for routine consultation and will be available for any emergency situation.

J. Transportation Service

Occasionally patients who have received therapeutic levels of radioactivity must be transported within the Medical Center. The risks associated with transportation of such patients are small, and results in a very insignificant exposure if the following procedures are followed:

- a. The individual transporting the patient shall be instructed of the better end from which to push the stretcher. The better end is the end that will position the transporter at the greatest distance from the radiation source.
- b. Transport the patient by the most direct route.
- c. The patient shall not be left in public waiting areas or corridors. If necessary the transporter shall remain in the area to keep other people at least 6 feet from the patient.
- d. When transporting the patient, do not share elevators with other staff or patients.
- e. Pregnant employees should not be used to transport radioactive patients.

Glossary

Activity: The number of nuclear disintegrations occurring per unit time in a radioactive material. The units of activity are the curie and the becquerel.

Adult: An individual 18 or more years of age.

Agreement State: A state, which has entered into an agreement with the U.S. Nuclear Regulatory Commission to assume regulatory responsibility for by-product materials and certain fissionable materials.

ALARA: Making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the activity is undertaken and taking into account:

- (a) The state of technology;
- (b) The economics of improvements in relation to:
 1. The state of technology;
 2. Benefits to public health and safety, and other societal and socioeconomic considerations; and
 3. Utilization of radiation and radioactive materials in the public interest.

Annual limit on intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given committed effective dose equivalent of 5 rems (0.05Sv) or a committed dose equivalent of 50 rems (0.05 Sv) to any individual organ or tissue. ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Schedule RHS 8-30.

Attenuation: The decrease in exposure rate of radiation as it passes through matter, as a result of absorption of radiation energy and of scattering.

Background radiation: The radiation in the natural environment, including cosmic rays and the radiation from the naturally radioactive elements, both outside and inside the body.

Bioassay (radiobioassay): The determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluations of materials excreted or removed from the human body.

Bremsstrahlung radiation: Electromagnetic radiation (x-rays) resulting from the interaction and resultant loss of energy by high energy electrons passing through the fields of nuclei.

Byproduct material: Radioactive material produced in nuclear reactors.

Committed dose equivalent (CDE) ($H_{T,50}$): The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50 year period following the intake.

Committed effective dose equivalent (CEDE) ($H_E,50$): The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Carcinogenesis: The induction of cancer.

Committed Dose Equivalent (CDE): Internal dose as measured with respect to an organ.

Committed Effective Dose Equivalent (CEDE): Dose to the whole body from the internal uptake of radioisotopes.

Cosmic rays: High-energy radiations originating outside the earth's atmosphere.

Daughter products: Isotopes that are formed by the radioactive decay of another isotope. For example, following the decay of radium-226 there are 9 successive radioactive daughter products, ending in the stable isotope lead-206.

Declared Pregnant Woman (DPW): A woman who has voluntarily informed her employer, *in writing*, of her pregnancy and the estimated date of conception.

Disintegration, nuclear (radioactive decay): A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus. When large numbers of nuclei are involved, the process is characterized by a definite half-life.

Deep Dose Equivalent (DDE): Dose to the whole body due to external radiation.

Dose Equivalent (H_T): The product of the absorbed dose in tissue, the quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Effective whole body dose equivalent (EDE or H_E): The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated.

Electromagnetic radiation: Radiation consisting of interacting electric and magnetic waves that travel at the speed of light. Examples are radio waves, TV waves, ultraviolet radiation, light waves, x-rays and gamma rays.

Electron capture: A mode of decay for radioactive nuclei in which an orbital electron is captured by the nucleus, converting a proton into a neutron.

Electron volt: A unit of energy. One eV is equivalent to the energy gained by an electron when accelerated by a potential difference of one volt. Multiples of this unit are commonly used for ionizing radiation, namely the kilo electron volt (keV) and mega electron volt (MeV).

External radiation: Radiation originating from radiation sources located outside the body. Compare to internal radiation.

Extremity: Hand, elbow, arm below the elbow, foot, knee or leg below the knee.

Eye dose equivalent: Applies to the external exposures of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm²).

Geiger-Mueller counter: A radiation detection instrument named for H. Geiger and W. Mueller, also called a Geiger counter or G-M counter. When ionizing radiation passes through the gas in the tube, a pulse of electrons is created which passes through an external electrical circuit and is counted.

Half-life, biological: The time required for the body to eliminate half of an administered dosage of any substance by regular processes of elimination.

Half-life, effective: The time required for a radionuclide contained in a biological system to reduce its activity by half as a combined result of radioactive decay and biological elimination.

Half-life, radioactive: Time for the activity of any particular radionuclide to be reduced to one-half of its initial value.

High radiation area: An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates.

Internal radiation: Radiation emitted by radioactive substances in the body.

Ionization chamber: An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber.

Ionizing radiation: Radiation capable of ionizing neutral atoms, i.e. displacing electrons from atoms or molecules, thereby producing ions.

Lens Dose Equivalent (LDE): Dose equivalent to the lens of the eye due to external radiation sources.

Minor: An individual less than 18 years of age.

Occupational dose: The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation and/or to radioactive material from registered, unregistered, licensee, registrant or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, or as a member of the general public.

Photon: A quantum or packet of energy in the form of electromagnetic radiation. Gamma rays and x-rays are examples of photons.

Prefixes for fractions or multiples of the basic units:

pico = p = 10^{-12}	kilo = k = 10^3
nano = n = 10^{-9}	mega = M = 10^6
micro = u = 10^{-6}	giga = G = 10^9
milli = m = 10^{-3}	tera = T = 10^{12}

Ex. 1 MeV = 1000 keV 1 mR = 0.001 R

25 uCi = 0.025 mCi 16 rads = 16,000 mrad

Radioactivity: The spontaneous emission of radiation from the nucleus of an unstable atom, as it transmutes into a more stable form. The amount of radioactivity is measured in curies or becquerels.

Radiation area: An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation or from any surface that the radiation penetrates.

Restricted area: An area, access to which is limited by the licensee or registrant for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart by the licensee.

Sealed source: A radioactive source sealed in a container or having a bonded cover, in which the container or cover has sufficient mechanical strength to prevent contact with or dispersion of the radioactive material. Radiation is emitted through the walls of the source.

Shallow Dose Equivalent, Maximal Extremities (SDE,ME): Dose to the extremities (ie. fingers, hands, feet, etc.) due to external radiation sources.

Shallow Dose Equivalent, Whole Body (SDE,WB): Shallow dose to the whole body due to external radiation sources.

Total Effective Dose Equivalent (TEDE): CEDE + DDE

Total Organ Dose Equivalent (TODE): The total internal dose with respect to the organ which receives the highest dose.

Whole body: For purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

Wipe test: A test for radioactive contamination in which the suspected surface or area is wiped with a filter paper (or other material), which is then tested for the presence of radioactivity. Also called a smear test or swipe test.

Appendix A
Acceptable Training and Experience for Medical Uses of Radioactive Material

A. Training requirements for physician to use or supervise the use of radioactive materials listed in Groups I, II, and III

The authorized user of a radiopharmaceutical, generator, or reagent kit must be a physician who:

1. Is certified in:
 - a. Nuclear medicine by the American Board of Nuclear Medicine;
 - b. Diagnostic radiology by the American Board of Radiology;
 - c. Diagnostic radiology or radiology by the American Osteopathic Board of Radiology;
 - d. Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
 - e. American Osteopathic Board of Nuclear Medicine in nuclear medicine; or
2. Has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of prepared radiopharmaceuticals, generators, and reagent kits, supervised work experience, and supervised clinical experience as follows:
 - a. 200 hours of classroom and laboratory training that includes:
 - i. Radiation physics and instrumentation; (approx. 100 hours)
 - ii. Radiation protection; (approx. 30 hours)
 - iii. Mathematics pertaining to the use and measurement of radioactivity (approx. 20 hours)
 - iv. Radiopharmaceutical chemistry; and (approx. 30 hours)
 - v. Radiation biology; and (approx. 20 hours)
 - b. 500 hours of supervised work experience under the supervision of an authorized user. For Group III (generators and reagent kits) experience should include personal participation in five (5) procedures to elute Tc-99m, including testing of eluate, and five (5) procedures to prepare radiopharmaceuticals from Group III reagent kits. that includes:
 - i. Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
 - ii. Calibrating dose calibrators and diagnostic instruments and performing checks for proper operation of survey meters;

- iii. Calculating and safely preparing patient or human research subject dosages;
 - iv. Using administrative controls to prevent the misadministration of byproduct material;
 - v. Using procedures to contain spilled byproduct material safely and using proper decontamination procedures; and
 - vi. Eluting technetium-99m from generator systems, measuring and testing the eluate for molybdenum-99 and alumina contamination, and processing the eluate with reagent kits to prepare technetium-99m labeled radiopharmaceuticals (applicants requesting authorization for Group III procedures should have personal participation in five (5) procedures to elute Tc-99m, including testing of eluate, and five (5) procedures to prepare radiopharmaceuticals from Group III reagent kits.) ; and
- c. 500 hours of supervised clinical experience under the supervision of an authorized user that includes:
- i. Examining patients or human research subjects and reviewing their case histories to determine their suitability for radioisotope diagnosis, limitations, or contraindications;
 - ii. Selecting the suitable radiopharmaceuticals and calculating and measuring the dosages;
 - iii. Administering dosages to patients or human research subjects and using syringe radiation shields;
 - iv. Collaborating with the authorized user in the interpretation of radioisotope test results; and
 - v. Patient or human research subject follow up; or
3. **Has successfully completed a six-month training program in nuclear medicine that has been approved by the Accreditation Council for Graduate Medical Education and that included classroom and laboratory training, work experience, and supervised clinical experience in all the topics identified in paragraph (2) of this section; or**
4. Physicians, dentists, or podiatrists identified as authorized users for the medical, dental, or podiatric use of byproduct material before April 1, 1987 who perform only those methods of use for which they were authorized on that date need not comply with these training requirements; or

5. A physician who, before July 1, 1984, began a three month nuclear medicine training program approved by the Accreditation Council for Graduate Medical Education and has successfully completed the program need not comply with these requirements; or
6. A physician that the Radiation Safety Committee (RSC) recognizes as having equivalent training and experience. Examples of documentation that the RSC will consider in its evaluation is documentation that the applicant has substantial previous experience at another institution or is listed as an Authorized User on a license issued by the Nuclear Regulatory Commission (NRC) for the types of procedures requested.

B. Training requirements for physician who wishes to be authorized for only one or two diagnostic procedures:

1. Group I (uptake, dilution, and excretion studies): The authorized user of a radiopharmaceutical in uptake, dilution, and excretion studies must be a physician who:
 - a. Has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of prepared radiopharmaceuticals, and supervised clinical experience as follows:
 - i. 40 hours of classroom and laboratory training that includes:
 - A. Radiation physics and instrumentation;
 - B. Radiation protection;
 - C. Mathematics pertaining to the use and measurement of radioactivity;
 - D. Radiation biology; and
 - E. Radiopharmaceutical chemistry; and
 - ii. 20 hours of supervised clinical experience under the supervision of an authorized user and that includes:
 - A. Examining patients or human research subjects and reviewing their case histories to determine their suitability for radioisotope diagnosis, limitations, or contraindications;
 - B. Selecting the suitable radiopharmaceuticals and calculating and measuring the dosages;
 - C. Administering dosages to patients or human research subjects and using syringe radiation shields;

D. Collaborating with the authorized user in the interpretation of radioisotope test results; and

E. Patient or human research subject follow-up; or

b. A physician that the Radiation Safety Committee (RSC) recognizes as having equivalent training and experience. Examples of documentation that the RSC will consider in its evaluation is documentation that the applicant has substantial previous experience at another institution or is listed as an Authorized User on a license issued by the Nuclear Regulatory Commission (NRC) or agreement state for the types of procedures requested.

2. Group II (imaging and localization studies) or Group III (Generators and reagent kits)

a. A physician should qualify under requirements of I(a) through I(e); or

b. Be a physician that the Radiation Safety Committee (RSC) recognizes as having equivalent training and experience. Examples of documentation that the RSC will consider in its evaluation is documentation that the applicant has substantial previous experience at another institution or is listed as an Authorized User on a license issued by the Nuclear Regulatory Commission (NRC) or agreement state for the types of procedures requested.

C. Training requirements for a physician who wishes to be authorized for only one or two diagnostic procedures to use or supervise the use of sealed sources of radioactive material

The authorized user of a sealed source in a device for bone mineral analysis which contains Iodine-125, americium-241, or gadolinium-153 must be a physician, dentist, or podiatrist who:

1. Is certified in:

a. Radiology, diagnostic radiology, therapeutic radiology, or radiation oncology by the American Board of Radiology;

b. Nuclear medicine by the American Board of Nuclear Medicine;

c. Diagnostic radiology or radiology by the American Osteopathic Board of Radiology; or

d. Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or

2. Has had 8 hours of classroom and laboratory training in basic radioisotope handling techniques specifically applicable to the use of the device that includes:

- a. Radiation physics, mathematics pertaining to the use and measurement of radioactivity, and instrumentation;
- b. Radiation biology;
- c. Radiation protection; and
- d. Training in the use of the device for the uses requested.

D. Training requirements for physician who wish to perform therapy procedures involving radiopharmaceuticals (Group IV and V)

The authorized user of a radiopharmaceutical for therapy procedures must be a physician who:

1. Is certified by:
 - a. The American Board of Nuclear Medicine;
 - b. The American Board of Radiology in radiology, therapeutic radiology, or radiation oncology;
 - c. Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
 - d. The American Osteopathic Board of Radiology after 1984; or
2. Has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of therapeutic radiopharmaceuticals, and supervised clinical experience as follows:
 - a. 80 hours of classroom and laboratory training that includes:
 - i. Radiation physics and instrumentation;
 - ii. Radiation protection;
 - iii. Mathematics pertaining to the use and measurement of radioactivity; and
 - iv. Radiation biology; and
 - b. Clinical experience for specific Group IV therapy procedures:
 - i. Iodine-131 for treatment of hyperthyroidism and/or cardiac conditions: Clinical experience in the diagnosis of thyroid function and active participation in treatment of ten (10) patients.
 - ii. Phosphorus-32 for treatment of polycythemia vera, leukemia and/or bone metastases: Active participation in the treatment of three (3) patients with any combination of these three conditions.
 - iii. Colloidal phosphorus-32 intracavitary treatment: Active participation in the treatment of three (3) patients.

- A. Clinical experience for specific Group V therapy procedures:
- B. Iodine-131 for treatment of thyroid carcinoma: Clinical experience in diagnosis of thyroid function, personal participation in the treatment of ten (10) patients with hyperthyroidism and/or cardiac dysfunction, and active participation in treatment of three (3) patients with thyroid carcinoma.
- C. Colloidal gold-198 for intracavitary treatment: Active participation in treatment of three (3) patients.
- D. Is a physician that the RSC recognizes as having equivalent training and experience. Examples of documentation that the RSC will consider in its evaluation is documentation that the applicant has substantial previous experience at another institution or is listed as an Authorized User on a license issued by the Nuclear Regulatory Commission (NRC) or agreement state for the types of procedures requested.

E. Training requirements for therapy procedures involving sealed sources

The authorized user of a brachytherapy source listed in Group VI for therapy must be a physician who:

1. Is certified in:
 - a. Radiology, therapeutic radiology, or radiation oncology by the American Board of Radiology;
 - b. Radiation oncology by the American Osteopathic Board of Radiology;
 - c. Radiology, with specialization in radiotherapy, as a British "Fellow of the Faculty of Radiology" or "Fellow of the Royal College of Radiology"; or
 - d. Therapeutic radiology by the Canadian Royal College of Physicians and Surgeons; or
2. Is in the active practice of therapeutic radiology, has had classroom and laboratory training in radioisotope handling techniques applicable to the therapeutic use of brachytherapy sources, supervised work experience, and supervised clinical experience as follows:
 - a. 200 hours of classroom and laboratory training that includes:
 - i. Radiation physics and instrumentation;
 - ii. Radiation protection;
 - iii. Mathematics pertaining to the use and measurement of radioactivity; and
 - iv. Radiation biology;

- b. 500 hours of supervised work experience under the supervision of an authorized user at a medical institution that includes:
 - i. Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
 - ii. Checking survey meters for proper operation;
 - iii. Preparing, implanting, and removing sealed sources;
 - iv. Maintaining running inventories of material on hand;
 - v. Using administrative controls to prevent the misadministration of byproduct material; and
 - vi. Using emergency procedures to control byproduct material; and
- c. Three (3) years of supervised clinical experience that includes one (1) year in a formal training program approved by the Residency Review Committee for Radiology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association, and an additional two years of clinical experience in therapeutic radiology under the supervision of an authorized user at a medical institution that includes:
 - i. Examining individuals and reviewing their case histories to determine their suitability for brachytherapy treatment, and any limitations or contraindications;
 - ii. Selecting the proper brachytherapy sources and dose and method of administration;
 - iii. Calculating the dose; and
 - iv. Post-administration followup and review of case histories in collaboration with the authorized user.

F. Training for physicians wishing to use Strontium-90 Ophthalmic Eye applicators only. The authorized user of only a strontium-90 ophthalmic eye applicator for therapy must be a physician who:

- 1. Is certified by the American Board of Radiology in radiology or therapeutic radiology; or
- 2. The authorized user of only strontium-90 for ophthalmic radiotherapy must be a physician who is in the active practice of therapeutic radiology or ophthalmology, and has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of strontium-90 for ophthalmic radiotherapy, and a period of supervised clinical training in ophthalmic radiotherapy as follows:
 - a. 24 hours of classroom and laboratory training that includes:
 - i. Radiation physics and instrumentation;(6 hours)

- ii. Radiation protection; (6 hours)
 - iii. Mathematics pertaining to the use and measurement of radioactivity; and (4 hours)
 - iv. Radiation biology; (8 hours)
- b. Supervised clinical training in ophthalmic radiotherapy under the supervision of an authorized user at a medical institution that includes the use of strontium-90 for the ophthalmic treatment of five individuals that includes:
- i. Examination of each individual to be treated;
 - ii. Calculation of the dose to be administered;
 - iii. Administration of the dose; and
 - iv. Followup and review of each individual's case history.

G. Training requirements for therapy procedures involving accelerators

The authorized user of a medical accelerator used for therapy must be a physician who:

1. Is certified in:
 - a. Radiology, therapeutic radiology, or radiation oncology by the American Board of Radiology;
 - b. Radiation oncology by the American Osteopathic Board of Radiology;
 - c. Radiology, with specialization in radiotherapy, as a British "Fellow of the Faculty of Radiology" or "Fellow of the Royal College of Radiology"; or
 - d. Therapeutic radiology by the Canadian Royal College of Physicians and Surgeons; or
2. Is in the active practice of therapeutic radiology, and has had classroom and laboratory training in basic medical accelerator techniques applicable to the use of a medical accelerator in therapy, supervised work experience, and supervised clinical experience as follows:
 - a. 200 hours of classroom and laboratory training that includes:
 - i. Radiation physics and instrumentation;
 - ii. Radiation protection;
 - iii. Mathematics pertaining to the use and measurement of radioactivity; and
 - iv. Radiation biology;

- b. 500 hours of supervised work experience under the supervision of an authorized user at a medical institution that includes:
 - i. Review of the full calibration measurements and periodic spot checks;
 - ii. Preparing treatment plans and calculating treatment times;
 - iii. Using administrative controls to prevent misadministrations;
 - iv. Implementing emergency procedures to be followed in the event of the abnormal operation of a medical accelerator unit; and
 - v. Checking and using survey meters; and
- c. Three years of supervised clinical experience that includes one year in a formal training program approved by the Residency Review Committee for Radiology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association and an additional two years of clinical experience in therapeutic radiology under the supervision of an authorized user at a medical institution that includes:
 - i. Examining individuals and reviewing their case histories to determine their suitability for medical accelerator treatment, and any limitations or contraindications;
 - ii. Selecting the proper dose and how it is to be administered;
 - iii. Calculating the doses and collaborating with the authorized user in the review of patients' or human research subjects' progress and consideration of the need to modify originally prescribed doses as warranted by patients' or human research subjects' reaction to radiation; and
 - iv. Post-administration follow up and review of case histories.

H. Training for an authorized nuclear pharmacist

The authorized nuclear pharmacist must be a pharmacist who:

- 1. Has current board certification as a nuclear pharmacist by the Board of Pharmaceutical Specialties, or**
- 2. a. Has completed 700 hours in a structured educational program consisting of both:**
 - i. Didactic training in the following areas:
 - A. Radiation physics and instrumentation;
 - B. Radiation protection;
 - C. Mathematics pertaining to the use and measurement of radioactivity;
 - D. Chemistry of byproduct material for medical use; and

- E. Radiation biology; and
- ii. Supervised experience in a nuclear pharmacy involving the following:
 - A. Shipping, receiving, and performing related radiation surveys;
 - B. Using and performing checks for proper operation of dose calibrators, survey meters, and, if appropriate, instruments used to measure alpha- or beta-emitting radionuclides;
 - C. Calculating, assaying, and safely preparing dosages for patients or human research subjects;
 - D. Using administrative controls to avoid mistakes in the administration of byproduct material;
 - E. Using procedures to prevent or minimize contamination and using proper decontamination procedures; and
- b. Has obtained written certification, signed by a preceptor authorized nuclear pharmacist, that the above training has been satisfactorily completed and that the individual has achieved a level of competency sufficient to independently operate a nuclear pharmacy; or
- c. A pharmacist who has completed a structured educational program as specified above before December 2, 1994, and who is working in a nuclear pharmacy would qualify as an experienced nuclear pharmacist. An experienced nuclear pharmacist need not comply with the requirements on preceptor statement and recentness of training to qualify as an authorized nuclear pharmacist.**

I. Recentness of training.

The training and experience specified in this section must have been obtained within the 7 years preceding the date of application or the individual must have had related continuing education and experience since the required training and experience was completed.

J. Groups of medical uses of radioactive material.

1. **Group I.** Use of prepared radiopharmaceuticals for certain diagnostic studies involving measurements of uptake, dilution and excretion. This group does not include uses involving imaging and tumor localization.
 - a. Iodine-123 as sodium iodide;
 - b. Iodine-125 as sodium iodide, iodinated human serum albumin, oleic acid or sodiumiothalamate;
 - c. Iodine-131 as sodium iodide, iodinated human serum albumin, labeled rose bengal, triolein, or sodium iodohippurate;
 - d. Cobalt-57 as labeled cyanocobalamin;
 - e. Cobalt-58 as labeled cyanocobalamin;

- f. Cobalt-60 as labeled cyanocobalamin;
 - g. Chromium-51 as sodium chromate or labeled human serum albumin;
 - h. Potassium-42 as chloride;
 - i. Sodium-24 as chloride;
 - j. Iron-59 as citrate;
 - k. Technetium-99m as pertechnetate; and
 - l. Any radioactive material in a radiopharmaceutical and for a diagnostic use involving measurements of uptake, dilution or excretion for which a “Notice of Claimed Investigational Exemption for a New Drug” (IND) has been accepted by the U.S. Food and Drug Administration (FDA).
2. **Group II.** Use of prepared radiopharmaceuticals for diagnostic imaging and localization studies.
- a. Iodine-131 as sodium iodide, iodinated human serum albumin, macro-aggregated iodinated human serum albumin, colloidal (micro-aggregated) iodinated human serum albumin, rose bengal or sodium iodohippurate;
 - b. Iodine-125 as sodium iodide or fibrinogen;
 - c. Iodine-123 as sodium iodide;
 - d. Chromium-51 as human serum albumin;
 - e. Fluorine-18 in solution;
 - f. Gallium-67 as citrate;
 - g. Gold-198 in colloidal form;
 - h. Mercury-197 as chlormerodrin;
 - i. Mercury-203 as chlormerodrin;
 - j. Selenium-75 as selenomethionine;
 - k. Strontium-85 as nitrate;
 - l. Strontium-87m as chloride;
 - m. Technetium-99m as pertechnetate, sulfur colloid, or macro-aggregated human serum albumin;
 - n. Thallium-201 as chloride;
 - o. Ytterbium-169 as pentatate sodium;
 - p. Indium-113m as chloride;
 - q. Any radiopharmaceutical prepared from a reagent kit listed in (c)3; and
 - r. Any radioactive material in a radiopharmaceutical and for a diagnostic use involving imaging or localizing for which a “Notice of Claimed Investigational Exemption for a New Drug” (IND) has been accepted by the U.S. Food and Drug Administration (FDA).
3. **Group III.** Use of generators and reagent kits for the preparation and use of radiopharmaceuticals for certain diagnostic studies.
- a. Molybdenum-99/technetium-99m generators for the elution of technetium-99m as pertechnetate;
 - b. Technetium-99m as pertechnetate for use with reagent kits for preparation and use of radiopharmaceuticals containing technetium-99m as provided in (c)3 and (c)5;

- c. Reagent kits for preparation of technetium-99m labeled:
 - i. Sulfur colloid;
 - ii. Pentatate sodium;
 - iii. Etidronate sodium;
 - iv. Human serum albumin;
 - v. Human serum albumin microspheres;
 - vi. Polyphosphates;
 - vii. Macroaggregated human serum albumin;
 - viii. Medronate sodium;
 - ix. Stannous pyrophosphate;
 - x. Gluceptate sodium;
 - xi. Oxidronate sodium;
 - xii. Disofenin;
 - xiii. Succimer.
 - d. In-113/indium-113m generators for the elution of indium-113m as chloride; and
 - e. Any generator or reagent kit for preparation and diagnostic use of a radiopharmaceutical for which generator or reagent kit a “Notice of Claimed Investigational Exemption for a New Drug” (IND) has been accepted by the U.S. Food and Drug Administration (FDA).
4. **Group IV.** Use of prepared radiopharmaceuticals for certain therapeutic uses that do not normally require hospitalization for purposes of radiation safety:
- a. Iodine-131 as iodide for treatment of hyperthyroidism and cardiac dysfunction;
 - b. Phosphorus-32 as soluble phosphate for treatment of polycythemia vera, leukemia and bone metastases;
 - c. Phosphorus-32 as colloidal chromic phosphate for intracavitary treatment of malignant effusions;
 - d. Any therapeutic material in a radiopharmaceutical for a therapeutic use not normally requiring hospitalization for purposes of radiation safety for which a “Notice of Claimed Investigational Exemption for a New Drug” (IND) has been accepted by the U.S. Food and Drug Administration (FDA).
5. **Group V.** Use of prepared radiopharmaceuticals for certain therapeutic uses that normally require hospitalization for purposes of radiation safety:
- a. Gold-198 as colloid for intracavitary treatment of malignant effusions;
 - b. Iodine-131 as iodide for treatment of thyroid carcinoma;
 - c. Any radioactive material in a radiopharmaceutical and for a therapeutic use normally requiring hospitalization for radiation safety reasons for which a “Notice of Claimed Investigational Exemption for a New Drug” (IND) has been accepted by the U.S. Food and Drug Administration (FDA).
6. **Group VI.** Use of sealed sources and devices containing radioactive material for certain medical uses:

- a. Americium-241 as a sealed source in a device for bone mineral analysis;
- b. Cesium-137 encased in needles and applicator cells for topical, interstitial, and intracavitary treatment of cancer;
- c. Cobalt-60 encased in needles and applicator cells for topical, interstitial, and intracavitary treatment of cancer;
- d. Gold-198 as seeds for interstitial treatment of cancer;
- e. Iodine-125 as a sealed source in a device for bone mineral analysis;
- f. Iridium-192 as seeds encased in a nylon ribbon for interstitial treatment of cancer;
- g. Strontium-90 sealed in an applicator for treatment of superficial eye condition;
- h. Radon-222 as seeds for interstitial treatment of cancer;
- i. Radium-226 encased in needles, applicator cells, and plaques for topical, interstitial and intracavitary treatment of cancer; and
- j. Iodine-125 as seeds for interstitial treatment of cancer

**Appendix B
Table of Radionuclides**

Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
³ H	12.35 Y	β	Low	80	1	-	-	Betas: 19 (100%)
¹¹ C	20.38 M	$\beta+$, EC	Low	400	1	5.97	13.7	Positrons: 960 (99.7%) Gammas: 511 (199.5%)
¹³ N	9.97 M	$\beta+$	Low		1	5.97	13.7	Positrons: 1,199 (99.8%) Gammas: 511 (199.6%)
¹⁴ C	5,730 Y	β	Moderate	2	1	-	-	Betas: 156 (100%)
¹⁵ O	122.24 S	$\beta+$	Low			5.97	13.7	Positrons: 1,732 (99.9%) Gammas: 511 (199.8%)
¹⁸ F	109.77 M	$\beta+$	Low	70	1	5.8	13.7	Positrons: 634 (96.7%) Gammas: 511 (193.4%)
²² Na	2.6 Y	$\beta+$, EC	High	0.4	0.01	12	26.6	Positrons: 545 (89.8%) Gammas: 511 (180%) 1,275 (99.9%)
²⁴ Na	15 H	β	Moderate	4	0.1	18.4	52	Betas: 1,390 (99.9%) Gammas: 1,386 (100%) 2,754 (100%)
³² P	14.29 D	β	High	0.4	0.01	-	-	Betas: 1,710 (100%)
³³ P	25.4 D	β	Moderate	3	0.1	-	-	Betas: 250 (100%)
³⁵ S	87.44 D	β	Moderate	2	0.1	-	-	Betas: 167 (100%)
³⁶ Cl	301,000 Y	β	High	0.2	0.010	-	-	Betas: 714 (98%)
⁴⁰ K	1.3 x 10 ⁹ Y	β , EC	High	0.3	0.1	0.7	38.7	Betas: 1,312 (89.3%) Gammas: 1,460 (10.7%)
⁴² K	12.36 H	β	Moderate	5	1	1.4	39.8	Betas: 1,996 (17.5%) 3,521 (82%) Gammas: 1,525 (18%)
DECAY MODES: α = Alpha Decay, β = Beta Decay, $\beta+$ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

**Appendix B
Table of Radionuclides**

Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
⁴⁵ Ca	163 D	β	Moderate	0.8	0.1	-	-	Betas: 257 (100%)
⁴⁶ Sc	83.83 D	β	High	0.2	0.01	10.9	29.1	Betas: 357 (100%) Electrons: 140 (38%) Gammas: 889 (100%) 1,121 (100%) 143 (62%)
⁴⁷ Ca	4.53 D	β	Moderate	0.8	0.1	5.7	34.4	Betas: 691 (81.7%) 1,988 (18%) Gammas: 489(7.0%) 808(6.9%) 1297(74.9%)
⁴⁸ V	16.24 D	β^+	Moderate	0.6	0.1	15.6	30.1	Positrons: 698 (50%) Gammas: 983 (100%) 1,312 (97.5%) 2,240 (2.4%) 511 (100%) 944 (7.7%)
⁵¹ Cr	27.7 D	EC	Low	20	1	0.2	6.3	Gammas: 320 (9.8%)
⁵⁴ Mn	312.5 D	EC	Moderate	0.8	0.1	4.7	24.6	Gammas: 835 (100%)
⁵⁵ Fe	2.7 Y	EC	Moderate	2	0.1	-	-	X-rays: 6 (28%)
⁵⁷ Co	270.9 D	EC	Moderate	0.7	0.1	0.9	0.7	Gammas: 122 (85.5%) 136 (10.6%)
⁵⁹ Fe	44.53 D	β	High	0.3	0.01	6.4	33.6	Betas: 273 (45.2%) 465 (53.1%) Gammas: 192 (3.0%) 1,099 (56.5%) 1,292 (43.2%)
⁶⁰ Co	5.27 Y	β	High	0.030	0.001	13.2	34.8	Betas: 318 (100%) Gammas: 1,173 (100%) 1,332 (100%)
⁶³ Ni	96 Y	β	Moderate	0.8	0.1	-	-	Betas: 66 (100%)
⁶⁷ Ga	3.26 D	EC	Low	7	1	1.1	4.7	Electrons: 84 (26.8%) Gammas: 93 (36%) 185 (19.7%) 300 (15.9%) 394 (4.5%)
DECAY MODES: α = Alpha Decay, β = Beta Decay, β^+ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

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Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
⁶⁸ Ge	288 D	EC	High	0.1	0.010	5.51	14.4	Positrons: 836 (84%) Gammas: 511 (178%) 1,077 (3.3%) 1,883 (0.1%) X-rays: 9 (39%) 10 (5.5%)
⁷⁴ As	17.76 D	β^+	Moderate	0.8	0.1	4.4	16.8	Betas: 718 (16%) 1,353 (19%) Positrons: 944 (27%) 944 (27%) 945 (27%) Gammas: 10 (5.1%) 511 (59%) 596 (60%) 608 (5.5%)
⁷⁵ Se	119.8 D	EC	Moderate	0.5	0.1	2.1	4.6	Gammas: 121 (16.7%) 136 (59.2%) 265 (59.8%) 280 (25.2%) 401 (11.4%)
⁸⁵ Kr	10.72 Y	β			1	0.4	2.8	Betas: 687 (99.6%) Gammas: 51.4 (43.4%)
⁸⁵ Sr	64.84 D	EC	Moderate	2	0.1	3.0	13.9	Gammas: 514 (99.2%) 15 (8.7%)
⁸⁶ Rb	18.66 D	β	Moderate	0.5	0.1	0.5	31.3	Betas: 698 (8.8%) 1,774 (94%) Gammas: 1,076 (8.8%)
⁸⁹ Sr	50.5 D	β	High	0.1	0	-	26.8	Betas: 1,491 (100%)
⁹⁰ Sr/Y	29.12 Y	β	Very High	0.004	0.0001	-	-	Betas: 546 (100%) 2,284 (100%)
⁹⁰ Y	64.0 H	β	High	0.4	0.01	-	-	Betas: 2,284 (100%)
⁹⁵ Nb	35.15 D	β	Moderate	1	0.1	4.3	22.5	Betas: 160 (100%) Gammas: 766 (100%)
⁹⁹ Mo	2.75 D	β	Moderate	1	0.1	1.8	20.5	Betas: 436 (17.3%) 1,214 (82.7%) Gammas: 181 (6.2%) 740 (12.8%)
^{99m} Tc	6.02 H	IT	Low	80	1	0.6	0.9	Electrons: 119 (8.8%) 137 (1.1%) Gammas: 140 (89%)
DECAY MODES: α = Alpha Decay, β = Beta Decay, β^+ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

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Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
¹⁰³ Pd	16.96 D	EC	Low	6	0.1	1.48	0.02	X-Rays: 20.1 (28.7%) 20.2 (54.4%) 22.7 (16.9%)
¹⁰⁹ Cd	464 D	EC	High	0.04	0.001	1.8	-	Electrons: 63 (42%) 84 (44%) 88 (10%) X-rays: 22 (84%) 25 (18%)
^{110m} Ag	249.9 D	IT, β	High	0.09	0.01	-	-	Betas: 22 (67.3%) 531 (30.5%) Gammas: 658 (94.4%) 678 (10.7%) 687 (6.5%) 707 (16.7%) 764 (22.4%) 818 (7.3%) 885 (72.6%) 938 (34.3%) 1,384 (24.3%) 1,505 (13.1%)
¹¹¹ In	2.83 D	EC	Moderate	4	0.1	3.4	2.2	Electrons: 145 (8.4%) 219 (4.9%) Gammas: 171 (90.2%) 245 (94%) X-rays: 23 (68%) 26 (15%)
¹¹³ Sn	115.1 D	IT	Moderate	0.5	0.1	1.7	0.05	Electrons: 20 (13%) X-rays: 24 (60%) 27 (13%)
^{115m} Cd	44.6 D	β	High	0.05	0.01	0.2	30.1	Betas: 616 (98%) 1,621 (98%)
¹²³ I	13.2 H	EC	Moderate	3	0.1	1.3	1	Electrons: 127 (13.6%) Gammas: 159 (83%) X-rays: 27 (70.6%) 31 (16%)
¹²⁵ I	60.14 D	EC	High	0.04	0.001	0.7	0.06	Electrons: 23 (19.7%) 31 (12.3%) Gammas: 35 (6.5%) X-rays: 27 (112%) 31 (25.4%)
¹²⁹ I	1.6 x 10 ⁷ Y	β	High	0.005	0.001	0.6	0.08	Betas: 152 (100%) Electrons: 34 (11%) Gammas: 40 (7.5%) X-rays: 30 (57%) 34 (13%)

DECAY MODES: α = Alpha Decay, β = Beta Decay, β^+ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer

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Table of Radionuclides**

Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
¹³¹ I	8.04 D	β	High	0.03	0.001	2.1	9.6	Betas: 334 (7.4%) 606 (89.3%) Gammas: 284 (6.2%) 364 (81.2%) 637 (7.3%)
¹³³ Ba	10.74 Y	EC	Moderate	0.7	0.1	2.4	5.8	Electrons: 45 (48%) 75 (7.4%) Gammas: 81 (33%) 276 (6.9%) 303 (17.8%) 356 (60%) 383 (8.7%) X-rays: 31 (97%) 35 (22.8%)
¹³³ Xe	5.25 D	β	-	-	1	0.1	0.4	Betas: 346 (99.3%) Electrons: 45 (53.3%) Gammas: 81 (36.5%) X-rays: 31 (38.9%)
¹³⁷ Cs	30.0 Y	β	High	0.1	0.01	3.5	18.9	Betas: 512 (94.6%) 1,173 (5.4%) Electrons: 624 (8.1%) Gammas: 662 (90%)
¹⁴¹ Ce	32.5 D	β	Moderate	0.7	0.1	0.4	0.9	Betas: 435 (71%) 580 (29.5%) Electrons: 103 (18.8%) Gammas: 145 (48.4%) X-rays: 36 (13.8%)
¹⁵⁰ Eu	34.2 Y	EC	High	0.02	0.001	-	-	Electrons: 5 (45.9%) 5 (45.9%) 6 (27.1%) 1 (150%) Gammas: 334 (94%) 584 (51.5%) 737 (9.4%) 748 (5.1%) 1,049 (5.2%) X-rays: 40 (65.4%) 45 (8.3%)
¹⁵² Eu	13.33 Y	β , EC	High	0.02	0.001	-	-	Betas: 696 (13.6%) 1,475 (8.4%) Electrons: 5 (73.4%) 33 (5.7%) 75 (19.5%) 114 (10.6%)
DECAY MODES: α = Alpha Decay, β = Beta Decay, β^+ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

**Appendix B
Table of Radionuclides**

Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
¹⁵³ Gd	242 D	EC	High	0.1	0.01	0.8	0.2	Electrons: 55 (32.2%) 49 (8.1%) 95 (5.1%) Gammas: 70 (2.6%) 97 (32%) 103 (22.2%) X-rays: 41 (100.5%) 47 (25.3%)
¹⁵⁴ Eu	8.8 Y	β , EC	High	0.02	0.001	6.3	29.1	Betas: 247 (27.9%) 569 (36.5%) 839 (17.4%) 1,844 (11.4%) Gammas: 723 (19.7%) 873 (11.5%) 1,005 (17.9%) 127 (35.5%)
¹⁶⁹ Yb	32.01 D	EC	Moderate	0.7	0.1	1.8	1.6	Electrons: 50 (34.9%) 100 (5.6%) 118 (10.3%) 120 (51.6%) 139 (12.4%) Gammas: 63 (42%) 110 (17%) 131 (12%) 177 (22%) 197 (36%) 307 (10%) X-rays: 50 (147%) 58 (39%)
¹⁸⁶ Re	3.78 D	β	Moderate	2	0.1	0.2	0.8	Betas: 1,070 (94%) 1,076 (71%) Gammas: 137 (9.5%)
¹⁸⁸ Re	16.98 H	β	Moderate	2	0.1	0.3	16.8	Betas: 2,120 (71.4%) Gammas: 155 (15%)
¹⁹² Ir	74.02 D	β , EC	High	0.2	0.001	4.8	20	Betas: 536 (41.4%) 672 (48.3%) Gammas: 296 (29%) 308 (29.7%) 317 (82.8%) 468 (48%) 604 (8.2%) 612 (5.3%)
¹⁹⁸ Au	2.7 D	β	Moderate	1	0.1	2.4	10.1	Betas: 961 (98.6%) Gammas: 412 (95.5%)
²⁰¹ Tl	3.04 D	EC	Low	20	1	0.4	0.9	Electrons: 84 (15.4%) Gammas: 167 (10%) X-rays: 69 (27.4%) 71 (46.5%) 80 (20.5%)
DECAY MODES: α = Alpha Decay, β = Beta Decay, β^+ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

**Appendix B
Table of Radionuclides**

Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
²⁰³ Hg	46.6 D	β	Moderate	0.5	0.1	1.3	4.7	Betas: 212 (100%) Electrons: 194 (16.9%) 264 (4.4%) Gammas: 279 (77.3%) X-rays: 71 (4.7%) 73 (8.0%)
²⁰⁶ Bi	6.24 D	EC	Moderate	0.6	0.1	17.2	26	Electrons: 96 (22.2%) 256 (5.6%) Gammas: 516 (40%) 803 (98.9%) 881 (66.2%) 1,719 (32%)
²⁰⁷ Bi	38 Y	EC	High	0.4	0.01	8.3	25.8	Electrons: 976 (7.0%) Gammas: 570 (97.7%) 1,064 (75%) 1,770 (6.8%)
²⁰⁸ Po	2.93 Y	α	High	0.014	0.000001	-	-	Alphas: 5,110 (100%)
²¹⁰ Pb	22.3 Y	β	Very High	0.0002	0.00001	0.0	0.2	Betas: 17 (80.2%) 63 (19.8%) Electrons: 8 (33.6%) 30 (57.9%) 43 (18.1%) Gammas: 11 (24%)
²¹⁰ Po	138.38 D	α	Very High	0.0006	0.0001	-	-	Alphas: 5,305 (100%)
²²² Rn	3.82 D	α	High	0.1	0.001	-	-	Alphas: 5,490 (99.9%)
²²⁶ Ra	1,600 Y	α	Very High	0.0006	0.0001	-	-	Alphas: 4,602 (5.6%) 4,785 (94.6%)
²²⁸ Th	1.91 Y	α	Very High	0.00001	0.000001	-	-	Alphas: 5,341 (26.7%) 5,423 (72.7%) Electrons: 9 (9.6%) 65 (19.1%) 80 (5.2%) X-rays: 12 (9.6%)
²³⁸ Pu	87.74 Y	α , SF	Very High	0.000007	0.000001	-	-	Alphas: 5,457 (28.3%) 5,499 (71.6%) Electrons: 10 (9.1%) 22 (20.7%) 38 (7.6%) X-rays: 14 (11.6%)
DECAY MODES: α = Alpha Decay, β = Beta Decay, β^+ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

**Appendix B
Table of Radionuclides**

Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	Γ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
²³⁸ U	4.5 x 10 ⁹ Y	α , SF	Very High	0.00004	0.1	-	-	Alphas: 4,147 (23%) 4,196 (77%) Electrons: 10 (8.2%) 29 (16.8%) 44 (6.1%) X-rays: 13 (9%)
²³⁹ Pu	24,065 Y	α	Very High	0.000006	0.000001	-	-	Alphas: 5,105 (11.5%) 5,143 (15.1%) 5,155 (73.3%) Electrons: 7 (19%)
²⁴¹ Am	432.2 Y	α	Very High	0.000006	0.000001	0.1	0.4	Alphas: 5,443 (12.8%) 5,486 (85.2%) Gammas: 60 (35.9%)
²⁴⁴ Cm	18.11 Y	α , SF	Very High	0.00001	0.000001	-	-	Alphas: 5,763 (23.6%) 5,805 (76.4%) Electrons: 10 (6.9%) 20 (17.2%) 37 (6.3%) X-rays: 14 (10.3%)
²⁵⁰ Cf	13.08 Y	α	Very High	0.000009	0.000001	-	-	Alphas: 5,989 (16.2%) 6,031 (83.4%) Electrons: 18 (12%) X-rays: 15 (7.8%)
²⁵² Cf	2.638 Y	α , SF	Very High	0.00002	0.000001	-	-	Alphas: 6,076 (15.2%) 6,118 (81.6%) Electrons: 19 (11.2%) X-rays: 15 (7.3%)
DECAY MODES: α = Alpha Decay, β = Beta Decay, β^+ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, Γ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

Appendix C

Radioactive Waste Disposal

PI's are responsible for ensuring that their staff is familiar with the rules and procedures governing the disposal of radioactive waste. All waste disposals must be accounted for on the accountability record that accompanies each order.

Radioactive waste is collected at the point of generation by VEHS and transported to the Hazardous Waste Management Facility. To request a waste collection, fill out the online "Radioactive Waste Collection Form" which can be found at www.safety.vanderbilt.edu/ or print it and fax it to 3-7036. The request must be received by 8:30 am to have the waste collected that same day.

Work involving radioactive materials should be carefully planned to minimize the volume of waste generated. Care must be exercised to separate radioactive waste from non-radioactive waste as it is generated. Non-radioactive waste must not be placed in radioactive waste container, as disposal of radioactive waste is very expensive.

Radioactive wastes must be stored only in restricted areas where they can be secured against unauthorized removal. Radioactive waste containers may not be left unattended in a corridor.

All receptacles for radioactive waste must be clearly labeled with an appropriate radiation warning sign.

Radioactive waste should not be allowed to accumulate in the lab. When a waste container is full, a waste collection request should be submitted to VEHS for quick removal.

If the radioactive waste contains gamma emitters or high-energy beta emitters, attention should be given to the location of the waste container in the laboratory to minimize radiation exposure of laboratory personnel. Additional shielding may be required.

Separate waste containers must be set up for short half-life and long half-life wastes. This will reduce waste disposal costs.

Normally, no charge is made to a PI for disposal of radioactive waste. All radioactive waste disposal charges will be billed back to the PI's school or major division (School of Medicine, VUH, Arts and Sciences, Engineering, etc.). However, if unusually large volumes or special procedures become necessary, the school might decide that the PI should bear the unusual charges.

Radioactive waste packaging procedures are complicated due to the license restrictions and cost structures of commercial radioactive waste disposal facilities. Specific waste packaging procedures are as follows:

1. VEHS inspects radioactive waste packaging at the time the waste is collected. If the waste is improperly packaged, then VEHS will not collect the waste. The PI is responsible for ensuring that the waste is properly packaged. If VEHS determines that there are violations of the waste packaging procedures, it is the laboratory's responsibility to repackage the waste.
2. Each waste container must have a completed waste disposal tag. Waste cannot be accepted by VEHS unless it has been properly identified and tagged. These tags are only available from VEHS and specific to the type of waste being generated (dry solid, liquid, biowaste, etc.). The tags can be requested on the Radioactive Waste Collection Form.
3. Solid and liquid radioactive wastes must be kept separate. The laboratory must have a waste container for dry solid waste and a container for liquid waste.
4. All dry radioactive waste must be packaged in a yellow, transparent bag with the radiation emblem on the outside. Waste contaminated with radionuclides with a half-life less than 90 days should be disposed in the large bags available from RPI. Incinerable waste contaminated with radionuclides with a half-life greater than 90 days should be placed into the small bags available only from VEHS (ask for them on your waste collection form). All non-incinerable waste bags must be securely sealed with strong tape and have a "Dry Solid" waste identification tag.
5. Radioactive syringe needles, broken glassware, and other sharps must be packaged in a sharps container, clearly marked for radioactive sharps only. Please tag radioactive sharps with the biohazard radioactive waste tag.
6. Liquid waste containers must be in a non-degradable container and have positive fitting caps that must be kept closed. Containers of liquid waste must be tagged with both radioactive Liquid and chemical waste tags (both are available from VEHS). Liquid waste must be separated into aqueous liquid waste and chemical liquid waste. Liquid waste other than scintillation vials cannot be accepted in small vials or syringes. It must be emptied into a bulk liquid container. All liquid waste containers must be placed in secondary containment (a tub or enclosure that will catch any leakage from the bottle).
7. Sewer disposal is not to be used as a primary means of disposal; it should be limited to rinse water or the disposal of large volumes of low specific activity liquid. Liquid radioactive waste being disposed via the sewer must be readily soluble in water or biologically dispersible. Sewer disposal is limited to 0.2 mCi (7.4 MBq) per day per PI. Sinks used for sewer disposal must be designated for this purpose by VEHS and labeled as a "Radioactive Hot Sink". If a lab worker is uncomfortable with the process of pouring low specific activity down the drain, VEHS will collect the radioactive liquid waste for disposal.

8. Biodegradable scintillation cocktail should be used whenever possible. A list of biodegradable scintillation cocktails is maintained on the VEHS web site www.safety.vanderbilt.edu. If your experiment requires EPA-hazardous scintillation cocktail (solvent based), you will need to request an exemption from VEHS.

Scintillation vial/fluids must be separated into the following four waste streams:

- Biodegradable cocktail with short-lived radionuclides (<90 day half-life)
- Biodegradable cocktail with long-lived radionuclides (>90 day half-life)
- EPA-hazardous cocktail with short-lived radionuclides (<90 day half-life)
- EPA-hazardous cocktail with long-lived radionuclides (>90 day half-life)

Liquid scintillation vials do not have to be emptied into a bulk liquid container. Keep the vials in the original box and trays. If there are no trays, seal the vials in a radioactive waste bag and place it in a box.

9. Mixed waste is radioactive waste mixed with hazardous chemicals. These wastes are not accepted for disposal by most commercial disposal facilities; therefore, they are difficult and costly to dispose of. Non-hazardous chemicals should always substituted whenever possible. Plans for proper disposal of mixed waste should be made in the design stage of the experiment. This may require special approval by the Radiation Safety Committee. Mixed waste requires both a radioactive liquid waste tag and the pink hazardous waste tag.
10. Radioactive waste containing infectious agents shall not be released from the laboratory unless it has been suitably deactivated.
11. Animal and tissue waste must be tagged with the Biowaste tag. The maximum weight of an animal carcass is 27 kg. For animal carcasses containing ^3H or ^{14}C , the maximum activity is 0.0005 mCi/gram (1.85 kBq/gram) of tissue. Disposal costs may be charged to the PI if activity is over this limit.
11. Special work hoods and exhaust systems must be used in operations involving the production of significant amounts of airborne wastes. Approval of the Radiation Safety Committee is required for these operations. Where maximum permissible concentrations may be exceeded, the investigator will be required to trap or otherwise limit the amount of airborne radioactivity released.

Appendix D
Emergency Procedures

Emergencies
Involving Radioactive Materials

For assistance contact:
VEHS at 322-2057 or
The VEHS Emergency Pager 835-4965

Emergency	Hazard	Immediate Precautions
SPILLS	With millicurie amounts, radioactive contamination hazards may be significant.	<ol style="list-style-type: none"> (1) Alert all people in area. (2) Confine spill immediately. (3) For major spills: Barricade area and notify VEHS. (4) Proceed with decontamination. Carefully survey area and all personnel.
PERSONNEL CONTAMINATION	Decontaminate promptly. Hazard is greatest if there are open wounds.	<ol style="list-style-type: none"> (1) Flush wounds eyes. Wash skin with soap and water. (2) Prompt action is necessary to minimize uptake and radiation dose. (3) Notify VEHS (4) Do not leave Vanderbilt with contamination on skin or clothing.
AIRBORNE RADIOACTIVITY	Uptake of radioactive material possible. Contamination easily spread.	<ol style="list-style-type: none"> (1) Shut off source of contamination, if possible. (2) Notify others to vacate the area. (3) Shut windows and doors. (4) Call VEHS (322-2057). (5) Shut off air handling unit (call Plant Operations).
ACCIDENTAL UPTAKE OF RADIOACTIVITY	Hazards vary with amount of uptake and toxicity of the radionuclide.	<ol style="list-style-type: none"> (1) Immediately contact VEHS (322-2057). (2) Action varies depending on radionuclide and chemical form.
FIRES INVOLVING RADIOACTIVITY	Internal hazard from airborne activity. Contamination may be spread by fire-fighting techniques.	<ol style="list-style-type: none"> (1) Notify all persons in area. (2) Activate nearest fire alarm. (3) Notify Security Department. (4) Attempt to extinguish fire if radiation & fire hazard is not serious. (5) Notify VEHS (322-2057).

Appendix E
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF RADIOLOGICAL HEALTH

NOTICE TO EMPLOYEES

In "STATE REGULATIONS FOR PROTECTION AGAINST RADIATION", the Tennessee Department of Environment and Conservation has established standards for your protection against radiation hazards and certain provisions for the option of workers engaged in work under licenses or registrations issued by the Department.

YOUR EMPLOYERS RESPONSIBILITY

Your employer is required to-

1. Apply these regulations to work under the license or registration. Licenses and Certified Registrations contain special conditions, which shall be considered in addition to these regulations.
2. Post or otherwise make available to you a copy of the Regulations, licenses, registrations, and operating procedures which apply to work in which you are engaged, and explain their provisions to you.
3. Post any written notice from the Department that the Regulations have been violated and response to such notice.

YOUR RESPONSIBILITY AS A WORKER

You should familiarize yourself with those provisions of the Regulations, and the operating procedures which apply to the work in which you are engaged. You should observe their provisions for your own protection and protection of your co-workers.

AREAS COVERED BY THESE REGULATIONS

1. Limits on exposure to radiation and radioactive material in restricted and unrestricted areas;
2. Measures to be taken after accidental exposure;
3. Personnel monitoring, surveys and equipment;
4. Caution signs, labels, and safety interlock equipment;
5. Exposure records and reports;
6. Option for workers regarding the Department's inspection; and
7. Related matters.

REPORTS ON YOUR RADIATION EXPOSURE HISTORY

1. The Department's 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 in the license. The basic limits for exposure to employees are set forth in Rules 1200-2-5-.50, 1200-2-5-.53 and 1200-2-5-.55 of the Regulations. These Rules specify limits on exposure to radiation and exposure to concentrations of radioactive material in air and water.

2. If you work where personnel monitoring is required and if you request information on radiation exposures;
 - a. Your employer must advise you annually of your exposure to radiation, and
 - b. Your employer must give you a written report, following terminations of your employment, of your radiation exposures.

INSPECTIONS

All licensed or registered activities are subject to inspection by representatives of the Department. In addition, any worker or representative of workers who believes that there is a violation of the Regulations or 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 Tennessee Department of Environment and Conservation, Division of Radiological Health L & C Annex, 3rd Floor, 401 Church Street, Nashville, Tennessee 37243-1532. The request must set forth the specific grounds for the notice, and must be signed by the worker or representative of the workers. 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.

POSTING REQUIREMENT

Copies of this notice must be posted in a sufficient number of places in every establishment where employees are employed in activities registered or licensed pursuant to Chapter 1200-2-10 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. These documents, including the Vanderbilt Radiation Safety Manual and the "State Regulations for Protection Against Radiation", are available to you in the VEHS Office, phone number 322-2057.

May, 2007 (Revised)