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Definitions

**Exposure** -- term used to describe the amount of ionization produced in air from a radiation source. The unit used for this measurement is Roentgen (R) or milliroentgen (mR). Most portable survey instruments measure exposure. Exposure rate measurements can be used to calculate dose or dose equivalent.

**Absorbed Dose** -- means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the Gray (Gy).

**Rad** -- is the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

**Gray** -- is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rad)

**Rem** -- is the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rad multiplied by the quality factor (1 rem = 0.01 sievert (Sv))

**Sievert** -- is the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sievert is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rem)

![Exposure in Air – Roentgen

Absorbed dose in Tissue
Dose Equivalent
Rem or Sievert

Absorbed Dose in
Matter – Rad or Gray]
Dose Equivalent -- is a measure of how much energy is absorbed by the body from radiation. It is a calculation that seeks to quantify the risk of biological effect on human tissue from ionizing radiation. Dose equivalent means the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv). 100 rem = 1 Sv. These are also the units reported on your dosimetry report and quantify how much dose you have received.

Deep Dose Equivalent (DDE) – DDE is the risk to the whole body from radiation that has enough energy to penetrate deep into the body and deposit its energy anywhere in the body. It is often called whole body dose, applies to external whole-body exposure and is the dose equivalent at a tissue depth of 1 cm.

Lens Dose Equivalent (LDE) – LDE is the risk to the lens of the eye from radiation that has enough energy to pass through the anterior structures and tissues covering the lens of the eye, and deposit its energy in the lens. It is the dose equivalent at a tissue depth of 0.3 centimeter, which is approximately the thickness of the cornea and conjunctiva, which cover the lens of the eye.

Shallow Dose Equivalent (SDE) – SDE is the dose equivalent, or risk, from radiation that has enough energy to pass through the dead layer of skin that we all have on our bodies, and deposit its energy in the live skin beneath. It applies to the external exposure of the skin of the whole body or the skin of an extremity and is taken as the dose equivalent at a tissue depth of 0.007 centimeter.

Effective Dose equivalent (EDE) -- is the sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. This important concept “normalizes” risk to the whole “being”, from the part of the body receiving radiation dose, and allows us to combine does to radiosensitive organs or tissues in the body, (external and internal) to account for total risk to the whole body.

Total Effective Dose Equivalent (TEDE) – TEDE is that total risk to the whole body from sources of radiation both inside and outside the body. It means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

MeV – Mega electron volt (1 million electron volts). Unit of measurement which quantifies the amount of energy carried by particulate or electromagnetic radiation, e.g. Cs-137 emits a 0.662 MeV gamma ray and P-32 emits a 1.7 MeV Beta particle.

Activity – when talking about radioactive material, the units of Curie or Becquerel (SI unit) or number of nuclear disintegrations per minute (dpm) are used to describe the quantity of material that is present.
1.0 Introduction
Most institutions that are licensed to use radioactive material (RAM) or radiation producing equipment follow the same general rules and regulations; however, you will find that each institution will implement these rules differently. The Radiation Safety Guide describes the radiation protection practices, procedures and policies applicable to the safe use of radioactive material at the University of Virginia (UVA).

2.0 The Importance of Radiation Safety
The improper or unsafe use of radiation emitting sources or equipment has the potential to create a health hazard for not only the user, but also for the public and the environment surrounding the area of use. The licenses that are issued to UVA by the State of Virginia (VDH) specify what material may be used and the procedures that must be followed when used. If you work with radioactive material, you must adhere to the safe work practices that are taught during training or that are described in this Guide and other policies issued by the Office of Environmental Health & Safety (EHS), Radiation Safety Program.

Radiation Safety is the responsibility of all users. Radiation safety policies are established for everyone’s benefit and implementation requires everyone’s support. All personnel using radiation sources are expected to become familiar with UVA radiation safety policies and procedures and to conduct their operations in accordance with them. Failure to adhere to these policies and procedures could lead to disciplinary action, including termination, and can jeopardize the University’s license to use radioactive material.

3.0 Radiation Safety Program Organization
3.1 Radiation Safety Committee (RSC)
For programs of large size and broad scope, VDH regulations (12VAC5-481-470) require the establishment of an administrative structure to supervise the possession and use of radiation sources on the license. This structure is independent of other administrative organizations within the University. A component of this structure, the Radiation Safety Committee (RSC), is charged with ensuring that licensed material will be used safely and in accordance with the license and applicable regulations.

The University’s RSC members are appointed by the Vice President for Research. The Committee is comprised of representatives of departments and divisions of the University that use or have management oversight over the use of radioactive material and radiation producing equipment. The Committee meets at least once each calendar quarter to review issues of importance to radiation safety.

The following issues must be reviewed by the Radiation Safety Committee:
• ALARA program to ensure radiation exposure levels are within acceptable limits
• Changes to the Broad Scope License
• Changes made to the facilities described in the University’s license
• Changes made to procedures described in the license
• Approval of Authorized Users (AU) and Principal Investigators (PI)

The RSC functions to provide guidance and information on the radiation safety program to executive management, ensures that adequate resources are provided by license management and assists the Radiation Safety Officer (RSO) in the development, implementation and maintenance of the radiation safety program.

3.2 Office of Environmental Health & Safety (EHS)

The Radiation Safety Program resides within the Office of Environmental Health & Safety (EHS). EHS maintains various licenses issued to the University and is responsible for ensuring that the use of licensed material is in compliance with the conditions of the license, its associated procedures and other regulations.

EHS is responsible for the implementation of a comprehensive radiation safety program. The goals of the radiation safety program are:

- to ensure that use of radioactive material is properly managed,
- to provide for the safety of the user and the environment, and
- to be responsive to the needs of the University community and the individual user.

The Radiation Safety Program’s primary objectives are to protect personnel and the general public from unwarranted radiation exposure, protect the environment by minimizing release of radioactive material in effluents, ensure compliance with all applicable VDH regulations and to monitor and advise in the safe use of radioactive materials and analytical X-ray producing equipment at the University. The radiation safety program’s responsibilities include:

- training personnel in the safe use of radioactive material;
- administering the personnel and environmental dosimetry program;
- procurement of all radioactive material;
- shipment and receipt of all radioactive material for the University;
- collecting, packaging, and disposing of all radioactive waste;
- performing routine laboratory inspections;
- commissioning and decommissioning of all radioactive material use areas; and
- emergency response.

The Radiation Safety Program is managed by the Radiation Safety Officer.
3.3 Radiation Safety Officer (RSO)
The University Radiation Safety Officer (RSO) has overall responsibility for ensuring that radioactive material is used safely at the University. The RSO is responsible for managing the radiation safety program, identifying radiation safety problems, initiating, recommending or providing corrective actions, verifying implementation of corrective actions, ensuring compliance with regulation, and recommending policy changes and enforcement actions to the RSC.

If you have any questions regarding the University’s license, procedures, policies, rules or regulations relating to radiation safety, please call the RSO at 434-982-4919.

4.0 Types of Licenses Issued to the University of Virginia
The University of Virginia is authorized by a license issued by VDH to procure, use and store radioactive material. VDH also regulates the use of X-ray producing equipment. This includes the use of X-ray, fluoroscopy, CT, accelerators, analytical X-ray equipment and other units that emit ionizing radiation.

4.1 Broad Scope
This license is the most extensive in our possession. It allows the University to use a wide variety of radioactive material in many different ways. This license covers the use of radioactive material in the academic schools, medical school, Health System, and other offsite locations.

4.2 Gamma Knife
This license is a specific license that allows the University to possess and use a gamma stereotactic radiosurgery unit for treatment and research. This license is under the purview of a separate RSO.

5.0 Categories of Radioactive Material (RAM) User in the Research Setting
There are three categories of radioactive material authorizations assigned for use of radioactive material in the research setting. These are: Principal Investigator (PI), Qualified User (QU) and General User (GU).

5.1 Principal Investigator (PI) for Possession and Use of Radioactive Material
The PI category is typically reserved for the Laboratory Director. A person designated as a PI may use and possess radioactive material as specified in a letter of authorization that is sent to him or her from the Chairman of the RSC. The PI is responsible for the safe, proper use and security of materials under his or her authorization and may supervise other individuals in the use of these materials.

The PI is the only category of user authorized to order radioactive material unless the PI has formally requested in writing to Radiation Safety that one or more of the Qualified Users in the PI's lab be authorized to order radioactive material.
The PI is the principal contact for all correspondence from the RSC and Radiation Safety Program. The PI’s responsibilities include, but are not limited to, assuring that:

- Lab surveys are performed properly and at the required frequency
- Contamination is controlled
- Exposure rates are controlled
- Work areas and equipment are properly controlled and labeled
- Radiation safety records are maintained
- Radiation workers in the lab have received required training and authorization
- Material is properly secured against unauthorized use or access
- Incidents and abnormal occurrences are promptly reported to Radiation Safety
- Radioactive material inventory is accurate
- Use is in compliance with applicable radiation safety rules and regulations
- During any extended absences (greater than one month), the responsibilities of the PI are transferred to a QU in the lab, or to another PI with approval from Radiation Safety.

5.2 Qualified User (QU)

This category of user is primarily intended for permanent faculty and staff members who wish to work with radioactive material and who are qualified by education and experience to use radioactive material independently. The responsibilities of the QU are the same as the PI (see above list), excepting the automatic approval to order material. The PI may delegate portions of radiation safety management responsibilities to a Qualified User in the lab. The PI may approve any QU in the lab for ordering material by indicating the same on the bottom of the QU application.

5.3 General User (GU)

Most individuals will be authorized as a General User. The GU can work independently with, or in the vicinity of, radioactive material, but cannot order radioactive material. The GU is not directly responsible for other lab personnel’s use of radioactive material and may not supervise an unauthorized individual’s use.

5.4 Inactive User

If an individual will not be working with radioactive material for an extended period of time, EHS will change the individual’s authorization status to inactive and will suspend their authorization to use radioactive material. This will exempt the individual from retraining requirements. Authorization can be re-activated by providing notification to Radiation Safety and completing radiation safety refresher training.
6.0 Radioactive Material for Medical Use

6.1 Authorized User (AU)
Additional regulations and training requirements apply to authorization for use of radioactive material in or on humans. In accordance with our Broad Scope license, the use of licensed material in or on humans shall be by an individual who meets the training and experience requirements in 12VAC5-481. These individuals must be approved by the RSC and designated as Authorized Users under our license.

6.2 Medical Use Qualified User
This designation is used for individuals who may administer radioactive material to humans but do not meet the training and experience requirements for AU. These individuals may administer radioactive material only under the supervision of an Authorized User and must receive instruction as specified in 12VAC5-481-1710 (e.g. Radiology residents, fellows, other Medical Specialty Board Certified Physicians, registered technologists in their respective fields: nuclear medicine, radiation physics, and nuclear cardiology.

6.3 General User
Any worker, student, physician in training, etc. who does not administer radioactive materials, but spends significant and continuous time in radioactive material use areas and is routinely present during the administration of radioactive materials. These individuals must meet basic radiation safety training requirements specified by Radiation Safety.

6.4 Medical Event Reporting
A medical event generally involves the delivery of a dose to a patient that was different than the planned dose, the dose was delivered to the wrong organ or was not within 20% of the prescribed dose. This can result from administration of the wrong amount, nuclide, wrong patient, etc. Any medical event, event, accident or injury involving radiation exposure to staff or patients shall immediately be reported to RSO to ensure that timely evaluation and appropriate actions can be taken. The RSO must make the determination as to whether a medical event may have occurred in accordance with VDH regulations regarding such events and must report such within time frames specified in the regulations.

The RSO will investigate the event through consultation with individuals involved in the event in order to make a determination. The Hospital's representative on the RSC as well as the appropriate department chair and the RSC Chair will be notified by the RSO about any events investigated and decisions made about reporting. The procedure for notification of any event shall be directly by phone to the RSO.

7.0 Training Requirements for Individuals Working with or in the Vicinity of Sources of Radiation
VDH regulations require that all individuals working with, as well as in the vicinity of licensed material or radiation producing equipment, must have adequate training and experience. Basic radiation safety training must be provided by the licensee.

**Good training is the key to reducing and maintaining low exposures to individuals.** Training allows an individual to make informed decisions regarding the acceptance of risk as part of his or her job and to use protective methods that will keep doses As Low As Reasonably Achievable (ALARA), thus minimizing risks.

The following must receive radiation safety instruction:

- individuals who work with radioactive materials as part of their job;
- individuals who routinely work with radioactive patients;
- individuals who could receive a radiation dose that is equal to or greater than 10% of any applicable dose limit;
- individuals assuming duties with or in the vicinity of radioactive materials or radiation producing equipment; and
- whenever there is a significant change in duties, regulation, and terms of the license or type of radioactive material or therapy device used.

Records of your training must be maintained and must include the date of the instruction or training, name of individual receiving instruction and name of the instructor.

Individuals who have not completed training and approval are not allowed to work independently with radioactive material. They may, however, work under the direct supervision of their Principal Investigator, Qualified User or Authorized User until they have completed their training requirements. These individuals must be provided dosimetry before working around radioactive material.

**7.1 Individuals with no previous experience**

These individuals must satisfactorily complete the following:

- Radiation Safety Training Course (RSTC)
- Radiation Safety Training Course Examination
- An application for the category of user desired

The RSTC is available as on-line training from the Radiation Safety website (https://ehs.virginia.edu/Radiation-Safety-Training.html). The Radiation Safety Guide Lecture is part of this course.

**7.2 Individuals with previous experience**

The Radiation Safety Training Course may be waived at the sole discretion of the RSO, or the Assistant RSO, based on the following:
The individual supplies documentation of training from the institution at which he or she was authorized to use radioactive material. A letter from that institution’s RSO or Radiation Protection Manager (RPM) must be provided that contains the following information:

- A statement attesting that the individual attended and completed the Radiation Safety Training Course offered by that facility
- A copy, or description, of the course syllabus
- Duration of the course in hours
- Date of the course
- The RSO, or RPM, signature
- This letter must be dated

The RSO or Assistant RSO is not bound to accept previous training even upon satisfactory evidence that a previous course was completed. Reasons for not waiving attendance at the UVA RSTC may be that the earlier training was not of sufficient scope or was over 7 years in the past.

If documentation of previous training is accepted and completion of the UVA RSTC is waived, the individual will be required to satisfactorily complete the following:

- Radiation Safety Guide Lecture
- An application for the category of user type desired

7.3 Individuals who are certified by specific examining boards

Individuals who are certified by the boards listed on the NRC’s medical licensee toolkit website, are exempt from the requirement for completion of the RSTC but must satisfactorily complete the following training:

- Radiation Safety Guide Lecture for Patient Care Staff
- An application for the category of user desired

7.4 Individuals attending, or who have attended, radiation safety training provided by the Radiological Physics Division of the Radiation Oncology Department

These individuals must satisfactorily complete the following:

- Radiation Safety Guide Lecture for Patient Care Staff
- An application for the category of user type desired

7.5 Other individuals who may require training

Ancillary personnel such as housekeeping staff, dishwashers, etc. may require radiation safety training under certain conditions. Individuals working special sources may require specialized training. Radiation Safety provides customized training for these groups of individuals. Please contact us for further information if you think you fall into this category.
7.6 Annual Retraining Requirement for All Radiation Workers
In addition to the initial training requirements, there is a retraining requirement. Anyone who uses radioactive material while working at UVA, must complete annual refresher training. During surveys or audits, Radiation Safety staff will remind all radiation workers of the need to complete the retraining. If a user fails to complete the required retraining, they may lose the authorization to work with radioactive material. Re-authorization can only be obtained by completing retraining. Re-training is available online through the Radiation Safety Program website (https://ehs.virginia.edu/Radiation-Safety-Training.html). A live lecture can be provided if a request is made to the Radiation Safety Program.

8.0 Radioactive Material Use Applications
Before an individual can become authorized for the use of radioactive materials, they must complete an application and submit to the Radiation Safety Program. These applications are available online through our website.

8.1 Blank Copies of Applications
Copies of the most current revision of each application are available on the Radiation Safety Program website: http://ehs.virginia.edu/Radiation-Safety-Forms.html.

8.2 Principal Investigator, Qualified User and Authorized User
Applications for QU must be signed by the applicant’s PI. Applications for AU or PI will be reviewed by the RSO, the Assistant RSO and/or the Health Physicist, and then by two members of the RSC. If approved during this initial review, the application will be submitted to the RSC for vote of approval.

Applications for Authorized User (along with a preceptor statement if necessary) must be submitted to the RSO to document that the individual meets the training criteria specified in 12VAC5-481. The application must be approved and the individual must be designated an Authorized User under our license by the RSC.

8.3 General User
The GU application must be signed by the applicant’s PI or AU. The application is reviewed by the RSO or the Assistant RSO and the user will be tentatively approved. The applicants will then be reviewed and approved by the RSC at the next meeting.

9.0 Radiation Safety Committee Letter of Approval
The Radiation Safety Program will review all applications for completeness and ensure that the necessary training requirements have been met. The RSO and/or
RSC must approve all applications before an individual may begin work with radioactive material.

Upon approval of your application, you will receive a letter from the RSO or Chair of the RSC authorizing you to work with radioactive material at UVA. You are encouraged to use the Radiation Safety Program as a resource. If you have any questions regarding the use of radioactive material or radiation producing equipment, please feel free to contact us.

10.0 Irradiator Use

Irradiators are devices designed to provide a uniform gamma dose to small biological samples, materials and animals. Most irradiators contain the following major components: a radioactive source, shielding, a sample chamber, and a control panel. Some models may have an air supply to provide the sample chamber with ventilation.

The irradiator in use at the University is designed to minimize the radiation reaching the exterior surface of the device. During normal operation of the University's irradiator, it presents minimal hazard to users. Irradiators do not cause induced radioactivity; in other words, the material subjected to the gamma radiation, at the energies produced by these irradiators, does not become radioactive.

Enhanced security programs for these devices are required by regulation. All individuals who wish to use the irradiator must contact the Radiation Safety Program at 434-982-4919 for scheduling its use.

11.0 Safe Use of Unsealed Licensed Material

All individuals working in a laboratory or other area where radioactive material is used or stored should follow the general rules for safe use that include:

- Wear a laboratory coat, or other protective clothing, and eye protection at all times in areas where licensed materials are used.
- Wear disposable gloves at all times when handling licensed materials.
- After each procedure or before leaving the area, monitor hands, shoes, and clothing for contamination in a low-background area.
- Do not eat, drink, smoke or apply cosmetics in any area where licensed material is stored or used.
- Do not store food, drink or personal effects in areas where licensed material is stored or used.
- Wear personnel monitoring devices, if required, at all times while in areas where licensed materials are used or stored.
- Dispose of radioactive waste only in designated, labeled and properly shielded receptacles.
- Never dispose of radioactive materials down sink drains or in regular trash receptacles.
- Never pipette by mouth.
• Store radioactive solution in clearly labeled containers.
• Secure all licensed material when it is not under the constant surveillance and immediate control of the user(s).

If using more than 1 mCi of phosphorus-32:
• The use of low-density plastic shielding in order to keep bremsstrahlung radiation to a minimum;
• A mandatory radiation survey and wipe test for radioactive contamination after each use;
• The use of extremity dosimeters;
• Performance of a dry run prior to performance of unfamiliar procedures, in order to preclude unexpected complications; and
• The use of eye protection for procedures that involve 10 millicuries or more.

If using more than 1 mCi of iodine-125 or iodine-131:
• A mandatory radiation survey and wipe test for radioactive contamination after each use;
• Bioassay performed for individuals working in the lab during the iodine use;
• The use of vented hoods for iodination and for the storage of the radioiodine; and
  • Performance of a dry run prior to performance of unfamiliar procedures, in order to preclude unexpected complications.

12.0 Research Protocols Involving Use of Ionizing Radiation in Humans

Research involving exposure of humans to ionizing radiation requires additional specific approval. These research protocols require review and approval by the Human Investigations Involving Radiation Exposure Subcommittee (HIRE) https://med.virginia.edu/radiology/resources/staff-resources/medical-physics-support/human-investigations-involving-radiology-exposure-hire-committee/ or the Radioactive Drug Research Committee (RDRC) http://ehs.virginia.edu/Radiation-Safety-RDRC.html before approval by the IRB.

13.0 Research Involving Use of Animals

The University requires that, before any investigator purchases/obtains and begins research involving vertebrate species of animal, an animal research protocol must be submitted for review and approval by the Institutional Animal Care and Use Committee (IACUC).

The IACUC office assists investigators in completing the appropriate animal research proposal forms. The website address for the IACUC is:

http://www.virginia.edu/vpr/iacuc/

The transportation of radioactive animals to and from the vivarium from different buildings utilizing vehicles must be performed by Radiation Safety staff. Housing of radioactive animals, including cage changes, is covered in the Center for Comparative Medicine SOP # 230 (Issue Date 8/2005, Revised Date 3/26/2019).
The PI is responsible for informing vivarium staff that they will be housing radioactive animals. They also must label the cages with the universal radiation symbol, the investigator’s name, name of the isotope, the dose (activity) of isotope, the date the isotopic material was injected and the date when 10 half-lives of decay will occur. If this information is not present on the cage, the vivarium staff should contact the RSO immediately. Vivarium staff are responsible for cage and rack changing. Only radiation safety personnel are authorized to declare these materials to be free of radioactivity. Only radiation safety personnel can remove radioactive carcasses.

14.0 Lab Approvals, Commissioning and Radionuclide Possession Limits

All radioactive material use areas and radionuclide possession limits must be approved by the Radiation Safety Program. Laboratory space may not be used for radioactive material work without proper approval. Only the PI or AU may request changes to items specified in their authorization.

14.1 Commissioning

The PI and AU application contains a section that requests information about the intended use of radioactive material. The application requests information on the amount of each nuclide that is to be used, the location of the use area(s) and the equipment that will be used. After a PI application has received final approval, a representative from the Radiation Safety Program will visit the lab and determine what is necessary to commission the lab. This typically includes:

- determining what signs and postings are needed;
- determining the number and type of solid waste containers needed;
- determining the number and type of liquid waste containers needed;
- setting the lab up with a Radiation Safety Notebook;
- determining the type of survey instruments that may be needed;
- explaining the types of radiation surveys that must be performed;
- determining the recommended frequency of radiation surveys (minimum of 1 survey per week while radioactive work is being performed);
- explaining the proper method for keeping material inventory accurate;
- reviewing, with the PI, the need for proper material security; and
- instruction on segregation of hazardous wastes.

During this visit, or subsequent one, a Radiation Safety Program technician will perform a lab “set up” at which time the lab will be provided with all required containers, postings, etc. After this is completed, work with radioactive material may proceed in the areas designated for use.
Failure to follow this procedure may result in violations of license provisions and State regulations. **You may NOT move RAM or RAM-contaminated items into a room before it is properly posted for radioactive work. Only Radiation Safety Program staff may commission a lab or radioactive workspace.**

14.2 **Lab Changes (room additions, deletions, etc.)**

After the initial lab set-up, the PI may add or remove rooms from his or her authorization by emailing or calling the RSO and providing the necessary information. The request will be processed and a visit to the lab must be scheduled. A Radiation Safety Program technician will visit the lab and review the request with a knowledgeable representative of the lab.

If desired, the request may be made in writing by completing the “New Location” Application and submitting it to the RSO. As in the initial process, the PI will be notified of the approval authorizing the change in use space.

14.3 **Nuclide and Possession Limit Changes**

Nuclides may be added and existing limits may be increased by contacting the RSO and providing the necessary information by email. All amendments to an existing authorization must be approved by the RSO. The request must be approved before the PI may place an order for the material requested. This type of request is normally approved within 3 working days.

14.4 **Signs and Postings in the Laboratory**

Radiation warning signs and postings are required by regulations and internal policy. They must not be removed or altered once they are posted by radiation safety personnel. If you discover a problem with any posting or sign, e.g. missing, damaged, or out of date, please call the Radiation Safety Program at 434-982-4919.

14.5 **Changes to the laboratory and in the type of experiments and protocols that are conducted**

Significant changes to the laboratory (e.g., use of different nuclides, different types of equipment, structural changes which affect nuclide use and new experiments) must be approved by the RSO. Significant increases in the amount of material used may increase the radiation hazard associated with use of the material.

Any experimental change that would result in the generation of an EPA listed hazardous chemical waste that would be “mixed” with radioactive waste must be carefully evaluated. Disposal of this type of waste can be extremely difficult and expensive. Please contact Radiation Safety if you plan to generate this type of waste.
15.0 Procurement and Receipt of Radioactive Material

All radioactive material used in research must be ordered and received through Radiation Safety, unless otherwise approved by the RSO. Radiation Safety staff will perform the required "check-in" of the material and will deliver it to the lab. This process is in place to ensure that the material is received in accordance with VDH regulations and to ensure that the package or contents have not been damaged during transportation. The check-in procedure also allows the Radiation Safety Program to ensure that the license possession limits are not exceeded and that the individual receiving the material is authorized to receive the material.

Please call Radiation Safety Program at 434-982-1919 if other arrangements are required for special shipments.

15.1 Purchase of Radioactive Material

Only orders requested by the PI/AU or Designated QU will be processed. At the time the order is placed, the Radiation Safety Program will verify that the PI/AU is authorized for the type and quantity of material to be received. Discrepancies will be corrected before the order is placed. Radioactive orders for academic use must be placed using the MarketPlace. Instructions for ordering radioactive materials through MarketPlace can be found here: [http://ehs.virginia.edu/Radiation-Safety-Order.html](http://ehs.virginia.edu/Radiation-Safety-Order.html)

For orders in the medical center, follow PeopleSoft purchasing guidelines.

15.2 Receipt of Radioactive Material that is Not Purchased

If you are expecting a shipment of radioactive material from another university or institution, that material must also be shipped to the Radiation Safety Program. Contact us for instruction on shipment, shipping address and other license requirements prior to having the material shipped from the other institution. As noted above, the Radiation Safety Program will verify that the PI/AU is authorized for the type and quantity of material to be received. Discrepancies will be corrected before the material is delivered.

15.3 Response when radioactive material is shipped directly to the lab

If material is inadvertently shipped directly to your lab, you must immediately contact the Radiation Safety Program and arrange for it to be properly processed.

15.4 Transfer of radioactive material within the university from one lab to another

Radioactive material may be transferred from one lab to another provided the following requirements are met:

- The receiving PI/AU is authorized to possess the type and amount of material that is being transferred (i.e., nuclide and millicurie amount) and that the
amount of nuclide to be received will not cause the PI/AU’s authorization limits to be exceeded.

- The receiving lab should notify the Radiation Safety Program prior to the transfer to obtain approval.
- The material has been properly packaged
- The material is clearly labeled as to isotope and amount and is packaged in a manner that will prevent it from leaking.
- The transfer has been approved by both PIs.

The Radiation Safety Program must transport the material from the current lab to the new lab ensuring the material is properly packaged, labeled and secured.

15.5 Safe Opening of Radioactive Material Packages
Packages which have been externally surveyed but not opened by the Radiation Safety Program must be opened promptly to confirm receipt of the correct material. The packaging and contents of the package should be inspected to determine if any damage to the contents has occurred.

It is recommended that the package be opened in a hood or other radioactive material work area with a prepared surface to contain any spills should they occur during package opening.

- Wear gloves and lab coat to prevent personal contamination
- Visually inspect the package for any sign of damage (e.g. crushed, punctured). If damage is noted, stop and notify the Radiation Safety Program.
- Open inner package to verify contents (compare requisition, packing slip and label on the bottle or other container). Check integrity of the final source container (e.g., inspect for breakage of seals or vials, loss of liquid, discoloration of packaging material, high count rate on smear) and perform a survey. If anything is other than expected is found (i.e.; exposure rate readings hire than expected or if there is any reason to suspect contamination, stop and notify the Radiation Safety Program at 434-982-4919.
- Record the receipt of radioactive material in your radioactive material inventory log in your Radiation Safety Notebook.
- Survey the packing material and the empty package for contamination with a radiation detection survey meter.

If contaminated, treat this material as radioactive waste and notify the Radiation Safety Program at 434-982-4919.

If not contaminated, remove or completely obliterate (i.e. unreadable) the radiation labels before discarding in the regular trash.

15.6 Shipment of Radioactive Material
The shipment of radioactive material is strictly regulated by the U.S. Department of Transportation and VDH. Material must be properly packaged, labeled and
surveyed before shipment. In addition, VDH requires UVA to have proof that the recipient is licensed to receive the material. In order to ensure that all of these requirements are met, only Radiation Safety Program staff are authorized to ship radioactive material to another facility that is outside of the immediate grounds of the University.

16.0 Radiation Safety Notebook and Radioactive Material Inventory

Each radioactive material use laboratory is provided with a Radiation Safety Notebook. This Notebook contains information regarding: radioactive material inventory, radiation surveys, blank forms related to radionuclide use, maps of the laboratory, waste disposal procedures, phone numbers for Radiation Safety and other information important to good lab practices and radiation safety.

Additionally, the Notebook contains your PI Radioactive Material Project Data Summary Sheet for authorized radionuclides, possession limits, approved rooms and personnel.

16.1 Radioactive Material Inventory

Wherever radioactive material is used or stored, an inventory of the material must be maintained. Whenever radioactive material is received, removed as waste or transferred to another lab, the lab inventory must be updated to reflect the change.

For radioactive material use in the laboratory setting, the Radiation Safety Program provides an inventory form for the laboratory to use. This form will be provided with delivery of radioactive material packages and should be kept in the laboratory Radiation Safety Notebook.

17.0 Safeguarding Radioactive Material

VDH regulations require that ALL radioactive material (including waste) must be secured from unauthorized removal or access. Considering the way in which research is conducted at the University, this is often the most difficult and inconvenient of all radiation safety policies. Because of incidents of personnel contamination/exposure at several other institutions and the threat of terrorism, the security of radioactive material has become a priority issue.

Those individuals involved in the use of the larger sealed sources here at the University must be particularly vigilant.

It is essential that everyone take responsibility for ensuring that all radioactive material is either under direct observation by authorized personnel, or when unattended, be secured (locked in a cabinet, refrigerator, room, etc.) at all times.

For additional information and requirements regarding security of radioactive material, please browse the "Security of Radioactive Material (FAQ)" page (http://ehs.virginia.edu/Radiation-Safety-Security.html).

17.1 Compliance with the Security Regulations
The test for compliance is straightforward: Can someone remove radioactive material from your area without you, or another person in your area, knowing it? If the answer is yes, then the security in your area of use is not satisfactory. That is the test that Radiation Safety Program staff will use in evaluating individual laboratory security plans. It is also the test that will be used when Radiation Safety Program staff conduct random security checks of radioactive material-use rooms and areas.

Do not hesitate to call or consult with Radiation Safety Program staff if any questions arise regarding the proper method for ensuring radioactive materials are secured at all times.

18.0 Occupational Radiation Dose Limits, Monitoring and ALARA

The University is required to limit doses to workers in accordance with 12VAC5-481-640.

18.1 Occupational Dose Limits

The maximum allowable radiation dose that a radiation worker may receive at the University of Virginia is shown in Column 2 (Annual Limit) of the table below.

<table>
<thead>
<tr>
<th>Tissue or Organ of interest</th>
<th>Annual Limit</th>
<th>ALARA Level I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole body; head; trunk including male gonads; arms above the elbow; or legs above the knee</td>
<td>5 rem</td>
<td>1 rem</td>
</tr>
<tr>
<td>Hands; elbows; arms below the elbow; feet; knee; leg below the knee; or skin</td>
<td>50 rem</td>
<td>10 rem</td>
</tr>
<tr>
<td>Lens of the eye</td>
<td>15 rem</td>
<td>3 rem</td>
</tr>
</tbody>
</table>

18.2 ALARA Letters

The radiation safety program strives, to the extent practicable, to maintain doses at levels that are As Low As Reasonably Achievable (ALARA). Workers’ doses are continually evaluated and when necessary, investigations are conducted which examine the adequacy of techniques and equipment used to minimize personnel doses.

If your doses exceed the ALARA levels shown in Column 3 above, you will receive an ALARA letter. You must provide a written response to this letter, which should include a description of methods that will be employed to reduce future doses.

If Radiation Safety does not receive a response, you may not be allowed to work with radioactive material until an ALARA letter response is received.
18.3 Dosimeter Guidelines for External Monitoring
Dosimeters are used to monitor the dose you receive while working with radioactive material or radiation producing equipment. Information obtained from your dosimeter allows us to evaluate the safety of your work environment and maintain doses ALARA.

**Wearing your dosimeter is important.** Not only does it provide you with a measure of the dose you receive while performing your work, but it also provides information that can alert us to the need for review of equipment performance and individual work practices. Ultimately, it is you who decides what dose level and corresponding risk is acceptable to you based on this information.

All individuals who have the potential to receive greater than 10% of the dose limits will be issued a dosimeter to monitor their dose. Before working with radiation producing equipment or radioactive material, you should contact the Radiation Safety Program at 434-982-4919 or visit our webpage regarding the need for a dosimeter.

18.4 Dosimeter Issuance Guidelines

For those individuals working in the research laboratory setting, dosimeters will be issued based on the nuclide and total activity that will be used. Please note that alpha and low-energy beta radiation will not be detected by these dosimeters and therefore, dosimeters are not issued to individuals using only alpha or low energy beta emitting nuclides. These types of radiation are not penetrating and do not contribute to whole body or deep doses.

Dosimeters will be issued to x-ray producing equipment users in the medical center in accordance with radiology and other medical center policies.

To be issued a dosimeter, you must first complete a dosimeter application (http://ehs.virginia.edu/Radiation-Safety-Dosimetry.html).

It is the responsibility of each department or PI to identify new users who will be working with sources of radiation and advise them to contact the Radiation Safety Program regarding the need for a dosimeter.

**All radiation dosimeters are issued by Radiation Safety.**

The following table will be used as guidance to determine if an individual should be issued a dosimeter to monitor external dose. The guidelines are generally based on total activity used in 1 month.

<table>
<thead>
<tr>
<th>Radioisotope(s)</th>
<th>Activity (mCi)</th>
<th>Type of Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-14, H-3, P-33 &amp; S-35</td>
<td>any amount</td>
<td>none required</td>
</tr>
<tr>
<td>P-32</td>
<td>&lt; 6 mCi</td>
<td>none required</td>
</tr>
<tr>
<td>Ca-45</td>
<td>Low Energy Gamma Ray Emitters ( &lt; 200 \text{ keV (e.g. I-123, I-125, Tc-99m, Tl-201)} )</td>
<td>High Energy Gamma Ray Emitters ( &gt; 200 \text{ keV (e.g. Cr-51, I-131, Co-60, Cs-137, F-18, N-13)} )</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>( &lt; 50 \text{ mCi} )</td>
<td>( &lt; 50 \text{ mCi} )</td>
<td>( &lt; 2 \text{ mCi} )</td>
</tr>
<tr>
<td>none required</td>
<td>none required</td>
<td>none required</td>
</tr>
<tr>
<td>( &gt; 50 \text{ mCi} )</td>
<td>( &gt; 50 \text{ mCi} )</td>
<td>( &gt; 2 \text{ mCi} )</td>
</tr>
<tr>
<td>ring dosimeter</td>
<td>ring and whole body dosimeter</td>
<td>ring dosimeter</td>
</tr>
<tr>
<td>( &lt; 30 \text{ mCi} )</td>
<td>( &lt; 30 \text{ mCi} )</td>
<td>( &lt; 5 \text{ mCi} )</td>
</tr>
<tr>
<td>ring dosimeter</td>
<td>ring dosimeter &amp; whole body dosimeter</td>
<td>ring badge &amp; whole body dosimeter</td>
</tr>
<tr>
<td>( \geq 30 \text{ mCi} )</td>
<td>( \geq 30 \text{ mCi} )</td>
<td></td>
</tr>
</tbody>
</table>

### 18.5 Proper Use of Dosimeters

If you are issued a dosimeter, you must comply with the following:

- Your dosimeter should be worn at all times while at work. It should be worn on the portion of the whole body which will receive the highest dose. The front or name side of the dosimeter must be facing the source of radiation.

- If you work with X-ray producing equipment and wear a lead apron, the dosimeter must be worn **outside** the apron at the **collar** level.

- Do not take your dosimeter home with you.

- Protect your dosimeter from radioactive contamination.

- Do not store or leave your dosimeter near radioactive material, stock vials or other exposing radioactive material.

- Do not loan it to a coworker; it is for the assigned individual’s use alone.

- DO NOT wear your dosimeters for personal medical exposures, i.e. do not take it to the dentist or physician if you are to receive x-rays.

- Do not intentionally expose it to radiation. The dosimeter and its subsequent reading is an official record and intentionally exposing it to radiation will result in an inaccurate record of your occupational dose.

- Do not disassemble it or otherwise tamper with it.

- Call EHS promptly if your dosimeter is lost, damaged, or destroyed.

- When a new dosimeter is received at the start of a new wear period, replace the old dosimeter with the new one. Do not wear the old dosimeter once a new one is received.
• Return your dosimeters to your department coordinator at the end of the wear period. The dosimeters will be collected by Radiation Safety personnel within 5 days of the end of the wear period. **An unreturned dosimeter provides no information.**

• When wearing ring dosimeters, always check to be sure that the label portion of the ring is facing the source of radiation. Fingers can act as shielding and affect the accuracy of skin and extremity doses recorded.

The Radiation Safety Program returns the dosimeters to a dosimetry vendor for reading and results are reported back to us. Each area has a designated dosimeter coordinator. Check with this individual regarding receipt and return schedules for dosimeters issued in your department. If your dosimeter is not returned on time, your department will be charged for late or unreturned dosimeters.

If you receive medical care that involves radioactive material, you should contact the Radiation Safety Program. You must continue to wear your dosimeter while at work. Any elevated readings reported on your dosimeter will be discussed with you and a notation can be made in your permanent dose record to address the dose received from the medical procedure.

If there is any change (increase or decrease) in the amount of activity or in the nuclides that you use, you should notify Radiation Safety so that we can re-evaluate your dosimeter needs.

**18.6 Pregnancy Policy/Guidance**

It is known that cells in the body that reproduce rapidly are more sensitive to radiation damage. The cells of the embryo/fetus are rapidly dividing during early development and are therefore, considered to be much more sensitive to radiation. The first three months of development are particularly critical. If you are considering becoming pregnant, you should review the Radiation Safety Protection webpage ([http://ehs.virginia.edu/Radiation-Safety-Pregnancy.html](http://ehs.virginia.edu/Radiation-Safety-Pregnancy.html)) for information on policies, risks and recommendations regarding exposure to radiation during pregnancy.

You may also wish to formally declare your pregnancy for radiation protection purposes. If you become pregnant and are working with or around radioactive material or sources of radiation, you should also inform your supervisor.

**Declaration of a pregnancy is voluntary and is accomplished by completing a Voluntary Declaration Form** available on the Radiation Safety website or through the program. You must also **review NRC Regulatory Guide 8.13 – Instruction Concerning Prenatal Radiation Exposure.** Once the form is completed and reviewed, Radiation Safety will monitor your occupational dose more closely by issuing an additional dosimeter to monitor the dose to the fetus. Upon declaration of a pregnancy, we will be required to ensure that the dose to the embryo/fetus during the entire pregnancy, due to occupational exposure, **does not exceed 500 mrem.**
Handling of radioiodine compounds, particularly when there is potential for volatilization of iodine, should be avoided for the term of the pregnancy. If you are uncomfortable with your work schedule during pregnancy or have concerns regarding your exposure during pregnancy, you should speak with your supervisor and/or the RSO.

18.7 Right to be informed of occupational exposure and bioassay results
You have the right to access your dosimeter records through our program at any time. The readings from each dosimeter are not routinely reported back to you. You will only receive notification of your dose if it exceeds a UVA ALARA level.

You should receive a dose report at the end of each year which summarizes the doses you have received during the year and the total dose received while working at UVA.

18.8 RSO Review of Need for a Dosimeter
Personnel exposures are reviewed by Radiation Safety Program staff after each wear period and dosimeter issue practices may be modified at any time. Based on exposure information, any of the following may occur:

- The type of dosimeter the user is issued may be changed.
- It may be determined that, based on radioactive material use levels, there is no need to wear a dosimeter.
- It may be determined that, based on radioactive material use levels, the user may have to wear more than one dosimeter.
- The wear period may change; it may extend to quarterly, or may shorten to monthly.

19.0 Bioassay
A bioassay is an evaluation of radioactive material in the body, either by direct measurement or by the analysis of biological samples. For example, a urine sample will be collected from individuals whose use of radioactive material exceeds a certain trigger level. When the Radiation Safety Program has determined that bioassays are required, a baseline evaluation should be performed prior to radioactive material use.

Bioassays may also be required following radioactive material spills or other release of radioactive material. Events that have the potential to cause an intake of radioactive material must be reported to the Radiation Safety Program so that bioassays can be obtained as soon as possible.

19.1 Radioactive Iodine
The University requires that all volatile iodine work be performed in a "fume hood insert" which is installed inside an approved fume hood posted with the radioactive
symbol. These inserts, typically constructed of Plexiglas, function as a primary "hood" and draw air first through an activated charcoal filter before exhausting it into the main volume of the permanent fume hood, thus trapping any volatile iodine.

EHS maintains a list of labs which currently have hood inserts, and can provide you with information on the purchase of an insert.

### 19.1.1 Radioiodine Use That Requires Bioassay

<table>
<thead>
<tr>
<th>Type of Operation</th>
<th>Activity handled at any one time or cumulatively over a period of 3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>bench top use, not in fume hood</td>
<td>volatile, dispersible or unbound</td>
</tr>
<tr>
<td></td>
<td>bound to non-volatile agent</td>
</tr>
<tr>
<td>use in an OEHS-certified fume hood</td>
<td>0.1 mCi</td>
</tr>
<tr>
<td></td>
<td>1.0 mCi</td>
</tr>
<tr>
<td></td>
<td>1.0 mCi</td>
</tr>
<tr>
<td></td>
<td>10.0 mCi</td>
</tr>
</tbody>
</table>

In addition to the individual(s) handling the material, it may be necessary to perform bioassays on individuals who work in close proximity to the radioiodine process being performed. This may include persons observing or assisting in the procedure. Determination of which individuals require a bioassay will be made by Radiation Safety staff.

### 19.1.2 Baseline and Follow-up Bioassays for Radioiodine Use

A baseline bioassay should be performed prior to beginning work with radioiodine in quantities stated above. An initial bioassay, i.e., the first bioassay after work was performed, should be conducted between 6 and 72 hours following the beginning of the radioiodine work. Therefore, it is important to schedule a bioassay with Radiation Safety as soon as possible when initial use is scheduled. Holidays, vacations, and weekends should be considered when planning radioiodine use. Bioassay frequency following initial use will be determined by Radiation Safety.

### 19.2 Bioassay for all Other Radionuclides

Use of more than 75 mCi of any unsealed radionuclide requires an evaluation by the Radiation Safety Program to determine if bioassay will be necessary. Radiation Safety Program staff should be contacted in advance of any such work to allow for the performance of baseline and post-work measurement.

### 19.3 Dose Calculation Based on Bioassay Measurements

Dose calculations may be performed on bioassay results and the dose may be added to the individual’s permanent exposure record.
19.4 Exception to the Requirement for Bioassay
Individuals who are administered radioactive material as a medical diagnostic or therapeutic procedure are not subject to bioassay

20.0 Radiation Survey Instruments
Selection of a radiation survey instrument must be based on the intended use. Instruments used for contamination surveys typically use a different type of probe and readout (cpm) than those used for exposure rate measurements (mR/hr). If you are unsure about the type of instrument, you will need to perform required surveys, contact the Radiation Safety Program for guidance. The program can assist you in choosing an appropriate instrument and can provide you with a list of vendors, products and price information. In general, a survey instrument should be capable of detecting the nuclide of interest, it should be easy to use, calibrate, and it should be reliable. Consult the table at the end of this Guide for additional information on selection of appropriate instruments.

Survey Instrument Guidance
The following table provides information on recommended instruments for performing surveys.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Type of radiation</th>
<th>Geiger Counter with Geiger tube</th>
<th>Geiger Counter with Pancake</th>
<th>Geiger Counter with NaI crystal</th>
<th>Liquid scintillation counter</th>
<th>Gamma Counter</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>Beta</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>C-14</td>
<td>Beta</td>
<td>N</td>
<td>Y*</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>S-35</td>
<td>Beta</td>
<td>Y</td>
<td>Y*</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>P-33</td>
<td>Beta</td>
<td>Y</td>
<td>Y*</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>P-32</td>
<td>Beta</td>
<td>Y</td>
<td>Y*</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>I-125</td>
<td>Gamma</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>I-131</td>
<td>Beta, Gamma</td>
<td>Y*</td>
<td>N</td>
<td>Y</td>
<td>Y*</td>
<td>Y</td>
</tr>
<tr>
<td>Cr-51</td>
<td>Gamma</td>
<td>Y*</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

N   =  Do not use this instrument  
Y   =  Recommended instrument  
Y*  =  Not recommended but may be acceptable if detector efficiencies have been determined.

Although I-125, I-131, and Cr-51 can be detected using a survey instrument with a Geiger Mueller probe attached, the counting efficiencies associated with these nuclides are very low. We recommend using either a sodium-iodide (NaI) probe with the survey instrument or a liquid scintillation or gamma counter for detection of these radionuclides.
20.1 Radiation Survey Instrument Calibration

All instruments used for radiation safety purposes should be properly calibrated and in good working order. Survey instruments (e.g. Geiger counters) must be in proper operating condition to ensure that surveys performed with these instruments are reliable and accurate. All instruments used to perform surveys must be calibrated annually and operationally checked before each use. The Radiation Safety Program can perform the required annual calibration on most instruments used at the University.

Geiger-Muller (GM) Counters are required to be calibrated annually. This will be performed by Radiation Safety Program staff or a pre-approved calibration company. After each calibration, a report will be returned with the GM and must be kept in the corresponding section of the Radiation Safety Records notebook. This report describes the instrument, which was calibrated (e.g. manufacturer, model and serial number). It also indicates which units must be used when reading and recording survey results and the efficiencies to be used for selected radionuclides. Efficiencies are also noted on the case of the GM. The normal background, which is a reading taken in a non-radioactive work area, is provided in CPM. The report also provides any special operating instructions.

A lab which purchases a new meter for performing surveys or brings an instrument from another institution, should call Radiation Safety Program staff so that the meter may be picked up for initial calibration and entry into the HP Assist database. During the initial calibration, nuclide specific efficiency factors will be determined if required.

Calibration Sticker

Survey instruments must have current calibration stickers. Laboratory personnel are responsible for calling our program to schedule an instrument for its yearly calibration. A sticker on the side or bottom of the unit indicates the instrument’s date of last calibration, the calibration due date and the initials of the person who performed the calibration. Always check the due date before using the instrument. If the calibration due date has passed, do not use the instrument. Call us immediately to arrange for calibration. The program can provide a loaner if necessary.

For liquid scintillation or gamma counters, refer to the unit's instruction manual and/or ask the manufacturer’s representative to perform a calibration.

Refer to the owner's manual for additional information on proper use and operation of the survey instrument. Most contamination survey instruments at UVA are calibrated in counts per minute (CPM). If you intend to perform exposure rate measurements, you will require an instrument that has been calibrated in mR/hr. Check the calibration sticker to confirm proper units for measurement. Survey measurements may only be made in the units that the instrument has been calibrated for (i.e. you cannot measure mR/hr with an instrument which has only been calibrated to provide a reading in cpm). Call our program for further assistance.

After our program has calibrated your GM, it will be returned with a "Notice of Calibration" memo. Keep this memo in the Radiation Safety Notebook.
Detector Efficiency:
Each detector has a unique efficiency. GMs from the same manufacturer with similar model numbers may have different efficiencies. Instrument efficiencies are determined by the Radiation Safety Program and are noted on the calibration sticker affixed to the instrument.

GM detectors are not considered acceptable survey instruments for detection of low energy beta emitters. $^3$H, $^{14}$C, $^{33}$P, and $^{35}$S surveys must be performed using swipes and counting in a liquid scintillation counter.

20.2 User responsibility
Each meter should be checked before use to ensure it is “in calibration”. A calibration sticker should be affixed to the meter, which shows the date of calibration, the date the meter is due for recalibration, the units in which it was calibrated, and any efficiencies that were determined. If the meter does not have a Radiation Safety Program calibration sticker affixed, if it is coming due for calibration, or if its calibration has expired, contact us so that it can be picked up, entered into the system, calibrated or recalibrated.

It is your responsibility to ensure that the meter is in calibration, the batteries are good (and are replaced otherwise), and that the unit is responding properly. If there are any problems with the function of your survey instrument, tag the instrument out of service and contact the Radiation Safety Program. Minor repairs can sometimes be performed by Radiation Safety Program staff.

Before each use, the following operational checks should be made:
Check calibration sticker to ensure meter is not out of calibration
Check calibration sticker to determine which units on the meter face should be used (i.e. cpm or mR/hr). The instrument is normally only calibrated to read in one or the other. Perform battery check (if batteries are low, change batteries, most take D cell batteries.)
Turn scale switch to appropriate scale and hold probe to check source in geometry specified on op-check sticker on the side of the meter. Reading should fall within range specified on the sticker.
If reading falls outside the range specified on the calibration sticker, do not use the instrument, call the Radiation Safety Program.

20.3 Liquid Scintillation Counters (LSC) and Gamma Counters
Fixed counting systems such as liquid scintillation counters and gamma counters may be needed to count wipes taken to assess potential laboratory contamination. The Radiation Safety Program does not calibrate LSCs or gamma counters. These instruments are usually purchased from the manufacturer with a "maintenance agreement". Calibration, repair, and maintenance should be arranged through the manufacturer or vendor of the machine. Factory representatives will typically calibrate and maintain these counters on an annual basis. If, however, you are having difficulty operating one of these machines or you are using a "new" radionuclide for which you have no detector (counter) efficiency, Radiation Safety can assist you.
If possible, avoid organic solvent-based scintillation cocktails as these incur a higher cost for disposal. Alternatively, eco-friendly cocktails can be used.

Liquid scintillation and gamma counters should be serviced annually. During this routine maintenance, the factory representative should check that the unit is functioning correctly and provide the owner with efficiency information. It is the responsibility of all users of liquid scintillation and gamma counters to maintain these counters if they are used for required surveys.

Scintillation counters may contain internal radioactive sources depending on the type of machine and must be decommissioned by Radiation Safety prior to disposal or transfer. If a new scintillation or gamma counter is purchased, please notify Radiation Safety.

Please feel free to call us if you have any questions regarding radiation detection equipment.

20.4 Dose Calibrators

If your work requires the use of a dose calibrator, you must ensure that the instrument is calibrated in accordance with the requirements of 12VAC5-481.

21.0 Radiation Surveys

Radiation surveys are performed to locate sources of radiation and to detect removable surface contamination in lab areas or on equipment, personnel and clothing. Surveys are required by regulation and the conditions of our license.

When work with radioactive material is performed in a laboratory, at least one survey is required to be performed and recorded each week.

All required surveys must be recorded in the Radiation Safety Records notebook. Every PI/Lab should have this notebook.

Areas and equipment that may be contaminated, such as the primary work bench(s), water baths, centrifuges, etc., used during the radioactive experiment, should be surveyed. The floor in front of the primary workbench, door handles, etc. should also be surveyed.

Surveys should be started in primary work areas and expanded radially. If the primary work area is free of contamination, the expanded survey area can be small. If contamination is detected in the work area, the expanded survey may need to encompass the entire laboratory.

Areas found to have unacceptable radiation levels or contamination must be shielded and/or cleaned as soon as possible. Radioactive contamination may be labeled with radioactive material warning tape and/or cleaned. Follow-up surveys must be performed to confirm that contamination problems have been corrected.

21.1 Radiation Survey Records

Always record surveys. A survey is considered incomplete if it is undocumented.

1. Complete all items on the University of Virginia Laboratory Survey Sheet;
2. Be sure to note the purpose of the survey. A routine weekly survey is different than a spill response survey. Check the box for routine daily/weekly surveys, after performing a regular weekly survey. Record all non-routine surveys as well. Record results of follow-up surveys as well and note as "Resurvey of spill." This survey confirms that the cleanup was successful.

3. Record survey results in blue or black ink and initialing each survey;

4. Use proper units (DPM or mR/hr units only), only pre-approved labs may use mR/hr;

5. record survey results numerically (descriptive expressions such as "not hot" or "background" are not acceptable);

6. Enter the full date (month, day and year) that the survey was performed.

7. Signature of person who performed the survey

The “no work this week box” should be checked if no work is performed during that week. No survey is required if no radiation work has been performed. Alternatively, a written comment may be provided if no work with radioactive material will be performed for a longer period of time (e.g. “No radioactive work will be performed from month/day/year until month/day/year.”) A notation should be made if work was performed and the weekly survey was missed. From a regulatory standpoint, it is better to indicate that a survey was missed rather than make no comment at all or enter a survey result when none was performed.

**Converting CPM units to disintegrations per minute (DPM) units:**

Contamination surveys must be recorded in units of DPM in the survey records. Survey results must contain numeric values; descriptive results (e.g. "background") are unacceptable.

The equation for converting CPM to DPM is:

\[
\frac{\text{CPM gross} - \text{CPM background}}{\text{detector efficiency}} = \text{DPM}
\]

**All survey records must be kept until the termination of your authorization.**

Regulations require that the University maintain all survey and use records indefinitely for the purpose of eventual decommissioning of facilities. **At the termination of an authorization,** survey records must be provided to OEHS for inclusion in the University-wide decommissioning records file.

**21.2 Exemptions from Radiation Surveys**

Radioactive material users may be exempted from the requirement to perform weekly radiation surveys if no material is used, or in any way manipulated, during the week or for an extended period of time. In this case an entry must be made in the survey records stating no work was conducted during the period noted. All other requests for exemptions from performing surveys are made to, reviewed by and approved by the RSO.
21.3 Radiation Survey Results

Labs working with high-energy beta and gamma producing radioactive sources must perform ambient radiation surveys with an appropriate survey meter. The unrestricted dose rate level may not exceed 2 mR/hr. If the measured dose rate exceed 0.1 mR/hr you must contact the Radiation Safety Program. These labs must also perform contamination surveys utilizing a survey meter.

Labs working with low energy beta producing radioactive material must perform contamination surveys with a liquid scintillation counter.

If your contamination survey indicates counts that are twice background, retake the wipes and contact the Radiation Safety Program if the counts are confirmed.

Contamination results may not exceed the following limits:

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Average</th>
<th>Maximum</th>
<th>Removable</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-125, I-129</td>
<td>1.7 Bq/100 cm² (100 dpm/100 cm²)</td>
<td>5.0 Bq/100 cm² (300 dpm/100 cm²)</td>
<td>0.3 Bq/100 cm² (20 dpm/100 cm²)</td>
</tr>
<tr>
<td>I-126, I-131, I-133, Sr-90</td>
<td>16.7 Bq/100 cm² (1,000 dpm/100 cm²)</td>
<td>50.0 Bq/100 cm² (3,000 dpm/100 cm²)</td>
<td>3.3 Bq/100 cm² (200 dpm/100 cm²)</td>
</tr>
<tr>
<td>Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.</td>
<td>83.3 Bq/100 cm² (5,000 dpm/100 cm²)</td>
<td>250 Bq/100 cm² (15,000 dpm/100 cm²)</td>
<td>6.7 Bq/100 cm² (1,000 dpm/100 cm²)</td>
</tr>
</tbody>
</table>

1 Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

2 As used in this table, dpm (disintegration per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

3 Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

4 The maximum contamination level applies to an area of not more than 100 cm².

5 The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.
22.0 Radiation Safety Violation Policy

A radiation safety violation occurs when established radiation safety practices or procedures are not being followed as described in internal UVA policy or applicable external regulations associated with the use of licensed material. These violations may occur in research labs, teaching labs and areas in the Medical Center where radioactive material is used for diagnosis and treatment.

22.1 Policy Overview

Radiation Safety policies and procedures are established by the Radiation Safety Program with oversight by the RSC. The RSO is appointed by the University’s Executive Vice President and Provost and is responsible for ensuring the safe use of licensed material. The RSO is responsible for managing the radiation protection program; identifying radiation protection problems; initiating, recommending, or providing corrective actions; verifying implementation of corrective actions; stopping unsafe activities; and ensuring compliance.

The RSO is delegated the authority necessary to meet those responsibilities, including prohibiting the use of radioactive material by employees who do not meet the necessary requirements and shutting down operations where justified by safety concerns. The RSO is required to notify management if staff do not cooperate and do not address radiation safety issues. In addition, the RSO is free to raise issues with VDH at any time.

You must call the Radiation Safety Program if any of the following types of events occur:

- radioactive material security events;
- radioactive material spills;
- lost or misplaced radioactive material;
- contamination of personnel by radioactive materials;
- unauthorized removal of material;
- radioactive waste removed with the regular trash;
- equipment contamination;
- missed radiation surveys; and
- discrepancy in inventory records.

It is important that notification be made promptly. Certain events such as loss of material may require immediate notification to VDH. Radiation Safety Program staff will review the above events as necessary, and institute required corrective actions.

Surveys/Inspections are conducted in all research and medical use areas in which radioactive materials are used or stored and are conducted either quarterly, semi-annually, or annually, depending upon the types and amounts of radioactive material
used. Radiation Safety staff perform a semi-annual comprehensive radiation protection audit in each lab. Radiation Safety Program staff utilize a Laboratory Survey Form or other audit form to identify violations and determine compliance. Labs that use large amounts of material may be audited with greater frequency as needed. These audits may include a review of records, postings, labeling, personal dosimetry use, training, housekeeping, survey meter calibration and a general contamination survey.

22.2 Radiation Safety Violation Enforcement Policy

Minor radiation safety violations* are typically identified during routine laboratory inspections and resolved through verbal or written communication between the PI, individuals working under the PI’s authorization and Radiation Safety Program staff. This process ensures that problems are promptly identified and corrected.

The Radiation Safety Program believes that there are good working relationships at UVA and that continued noncompliance with established safety rules is a rare occurrence. The Radiation Safety Program recognizes the possibility of a problem and has established a follow-up enforcement program.

Violations of a serious nature**, or those that are not resolved in a timely manner, are presented to the RSC for discussion. The responsible PI or AU may be requested to appear before the RSC to report on what occurred, why it occurred and how they intend to prevent a recurrence and ensure safe continuation of the authorization.

* Examples of minor violations include: training not current, unlabeled equipment (i.e., freezers), food and drink violations.

** Examples of serious violations may include: posing immediate harm to the health or safety of employees, students, the public, or the environment, a serious deviation from Radiation Safety policy or procedures, or knowingly failing to apply for authorization to conduct research with radioactive material or administer radioactive material to humans.

22.3 Notification of Violations

Following an inspection or investigation, any violations or recommendations are reviewed with the PI or lab representative present during the survey. They are then asked to sign the Laboratory Survey form acknowledging that they have been informed of the violations and required corrective actions.

Radiation Safety Program staff will conduct a complete and thorough review of the circumstances that led to the deficiency or violation. They will talk with personnel involved, review relevant procedures for completeness or need for revisions, and review the training of those involved to see if a lack of training may have contributed to the problem. If they are not routine or reoccurring situations, they are usually corrected during or shortly thereafter and do not present further problems.

22.4 Violation Follow-up Procedures and Investigations
The Radiation Safety Program staff surveyor and/or survey supervisor will determine if violations found during laboratory inspections must be followed-up with increased surveillance and in-services as appropriate to ensure the violations are corrected. All follow-up activities will be recorded on the Laboratory Survey Violation Follow-Up Form. Repeat violations will be reported to the Radiation Safety Program Survey Supervisor and the RSO. The follow-up survey frequency will be determined by the Survey Program Supervisor. The Survey Program Supervisor will determine when to terminate increased surveillance based on personal observation and staff recommendations.

Follow-up communications and laboratory inspections are regularly performed based upon the severity of the violation until all deficiencies are addressed. In the event these same problems reoccur, a more aggressive approach needs to take place to find the cause of the problem(s), rectify the situation, and take measures to ensure that these conditions do not occur again in the future. In situations where satisfactory resolution is not achieved in a timely manner, notifications may be elevated to the, director, department chairperson or the RSC.

If an investigation is necessary, the RSO may obtain additional information by direct communication with the PI, contact person, co-workers, etc., review of laboratory procedures, training records, or via other related lab/facility documents. In some cases an unannounced visit to a laboratory of concern may be prudent.

The RSO may suspend activities if there is a significant threat to public health or compromise of safety and regulatory compliance. Radiation Safety will work with the RSC to bring all activities into compliance. Committee enforcement or disciplinary action may include but is not limited to: a letter of reprimand from the RSC Chair or RSO, mandatory retraining, and suspension or termination of RSC approval and/or privileges.

22.5 Reporting violations and investigations
Violations are documented and lab inspection results are entered into the radiation safety program management database. Survey and audit findings are reported to the RSC during the quarterly meetings.

Incident reports are kept on file by the Radiation Safety Program. Incidents may be reported to VDH if required by regulation.

Reporting mechanisms:
- Any individual who has concerns may contact the RSO by email or phone
- Report through the EHS website for accidents or safety concerns: https://researchcompliance.web.virginia.edu/report/user/concern.cfm
- By direct observation from Radiation Safety Program staff during inspections or routine outings
- During an incident investigation where additional violations are observed
If an individual identifies an issue that presents a significant risk to human health and safety or to the license; they are strongly encouraged to self-report such findings to the RSO. The Radiation Safety Program maintains a positive safety culture commensurate with the safety and security significance of our activities and makes available through its website (http://ehs.virginia.edu/Radiation-Safety-Culture.html) a Safety Culture Policy Statement describing programs and practices in place at the University that support the organizational traits deemed necessary for the existence of a positive safety culture. Any employee, student, or associate of UVA reporting a Radiation Safety-related concern will be protected against reprisal. Every effort will be made to protect the individual’s confidentiality in accordance with UVA policy.

22.6 Misconduct
Fabrication, falsification, plagiarism, or other practices that seriously deviate from those that are commonly accepted within the research community for proposing, conducting, or reporting research are considered research misconduct. Where there is willful or negligent violation of established radiation safety practices and procedures, or if a PI continues research activities after notification by the RSO to cease and desist, it may be deemed research misconduct. The Research Integrity Officer will be notified for administrative review and determination of action. Refer to the UVA Policy on Research Misconduct (RES-004 http://uvapolicy.virginia.edu/policy/RES-004) for more information.

23.0 Obligation to Report Unsafe Conditions to RSO
All radiation workers have an obligation to report any unsafe conditions in their workplace. Your safety, your coworker’s safety and the safety of the surrounding general public is jeopardized if unsafe work conditions are not corrected. You also have a responsibility to report promptly any condition which may lead to or cause a violation of Commission regulations or unnecessary exposure to radiation and or radioactive material.

All spills involving radioactive material must be reported to the Radiation Safety Program at 434-982-4919.

You must notify the RSO immediately if any of the following occur:

- Routine surveys of the work area identify unexpectedly high or low radiation levels, or unexpectedly high or low contamination levels. (Note: unexpectedly low exposure rates could indicate that material has been moved or stolen or your instrument is not functioning properly)
- Medical event
- A patient or human research subject (involving use of radioactive material or sources) has a medical emergency or dies
- Loss or theft of any radioactive material or sources
24.0 Locations where Important Documents, Notices, etc. are Posted

Workers have both the right and the responsibility to report unsafe work conditions or violations of the license, without fear of penalty. Radiation Safety Program staff are always available to evaluate such concerns. Additionally, VDH provides a Notice to Employees form that contains instruction to workers on these matters. This form is posted in all radioactive material use areas.

VDH regulations pertaining to use of radioactive material and radiation producing equipment (12VAC5-481) may be found on the Virginia Department of Health/Radiological Health Program’s or the Radiation Safety Program website. The State licenses, license conditions or documents incorporated into our license and all amendments, the operating procedures applicable to licensed activities and any notices of violation issued by VDH are available for review at the Radiation Safety Program.

25.0 Radioactive Waste

Radiation Safety Program provides all radioactive waste containers, radioactive waste pickup services and consultation. To request a radioactive waste pickup, email the electronic ticket to ehs-radwaste@virginia.edu. You may also call the Radiation Safety Program at 434-982-4919. The waste ticket must include the following information:

♦ Name of caller
♦ PI name and PI number
♦ Today’s date and lab phone number
♦ Waste location: building and room
♦ Waste container size, radionuclide(s) and activity in mCi
♦ Type of container to be replaced or emptied
♦ Indicate the presence of contamination
♦ Note any problems with the waste.

Radioactive waste will be picked up on scheduled weekdays. Free (unbound) Iodine-125, high-activity waste and biological waste will be picked up on an expedited schedule. To expedite pickup, please call Radiation Safety before generating these types of wastes.

Please do not stockpile any radioactive waste. Submit waste requests regularly, even if the container(s) are not full. Regular removal of waste reduces radiation exposure to lab occupants and reduces the likelihood that waste content knowledge will be lost.

♦ Radioactive waste must be segregated by radionuclide.

Each radionuclide has a unique half-life and environmental release limit. Improper co-mingling of radionuclides can delay the disposal of waste and may necessitate shipment of the material to a radioactive waste repository at a significantly greater cost to the University. Please contact Radiation Safety if you find it necessary to co-
mingle radionuclides. It may be done only if it does not impact the University's waste processing and reduction program.

The University of Virginia's license requires waste containing isotopes with half-lives greater than 120 days (e.g. Co-57, Co-58, Na-22, Cl-36, Zn-65), to be shipped offsite for disposal. Radiation Safety will advise your lab on methods to minimize waste containing long-lived isotopes.

♦ Radioactive waste must be segregated by physical form.

**Dry Solids:** This category includes such items as contaminated paper, plastic, glass, and metal. **No standing liquids or blood-contaminated items are allowed in our solid waste boxes. A small volume of liquid (< 50 ml total) is permissible in the dry solid waste container.**

Do **not** place Sharps in solid waste boxes. Sharps must be placed in approved and radioactively labeled sharps containers (provided by Radiation Safety) prior to disposal. The closed sharps containers may then be placed in the solid waste boxes.

**Waste Scintillation Vials:** All scintillation vials must be placed in trays and treated as a separate waste item with its own waste ticket. Vials containing radionuclides with half-lives greater than 120 days, i.e. Carbon-14 ($^{14}$C) or Tritium ($^3$H), must be segregated from other radionuclides and placed back in the empty cardboard tray they were received in. Carbon-14 and H-3 vials may be placed in the same tray. Clearly label each tray with the radionuclide name. Label the tray with radioactive warning tape. Place the waste vials in the tray in an up-right position and ensure that they are securely capped to minimize spills. Be sure to keep the cardboard tray in secondary containment (e.g. in a tray) in case of spills.

**Organic Solvent-Based Scintillation Vials:** Organic solvent-based scintillation fluors must be packaged separately. Since these vials may leak, do not store this waste for long periods of time.

Complete a waste ticket in the same manner you would for other forms of radioactive waste and be sure to check the “**liquid**" check-box and indicate you have scintillation vials to be picked up. If your lab does not purchase scintillation vials in cardboard trays, or you do not have empty trays available for your waste, please contact our program and they will be provided to you.

**Bulk Liquids:** Any liquid whose volume is greater than 50 ml is defined as a bulk liquid.

- Use a separate waste container for each nuclide.
- Separate aqueous from organic liquid waste.
- Record all chemicals contained in the waste, along with measured pH.
- Do not overfill waste containers.
- Leave room for potential expansion of the waste.
- Do not place solid material (e.g. biological material, filter paper, pipette tips) in your liquid waste. Obstructions in the spout can create a splashing and disposal hazard.
- Try to reduce the amount of acidic waste, which can damage containers.
• Add bleach or use other methods to neutralize biological liquid waste (e.g. blood, urine, cells).

Use a funnel when pouring liquid into the waste container to prevent spills and minimize contamination on the outside of the container.

When washing contaminated glassware, etc. you must collect the first rinse wash water and place in the radioactive liquid waste container. Count a sample of subsequent rinse water if you suspect significant remaining contamination before washing as usual. Never pour radioactive material down the lab sink.

**Stock Vials, Other Vials or Capped Containers (< 50 ml):** Vials and other capped containers with less than 50 ml of liquid may be disposed in the dry solid waste container. Note: Stock vials (with <50ml) may be placed in dry solid waste, however, the lead containers they come in must not go into the waste box. The lead must be kept separate and can be picked up by Radiation Safety as a separate waste item. Old stock vials should not be stockpiled. Dispose of them promptly if they will no longer be used or have expired.

**Biological Tissue:** This waste includes animal bedding and blood soaked items. These items must be packaged to prevent leakage. Sharps must be put in an approved sharps container. Freeze or refrigerate this waste, when possible, until pickup.

**Radioactive/EPA classified hazardous chemical waste.** All labs that generate waste that is both radioactive and is an EPA classified chemical waste must consult our program for proper disposal instructions to ensure that all local, state and federal regulations are followed. Containers that will be used for disposal of mixed hazardous material must be provided by Radiation Safety. Mixed hazardous waste must be clearly described on the waste ticket. Do not place this type of waste in a radioactive waste container.

**Lead:** Lead is a hazardous material and must be separated from other types of waste. Place lead in a box, label as lead waste, and call Radiation Safety for pickup.

**Waste Handling and Disposal Procedures**

♦ **Package radioactive waste in appropriate containers.** The Radiation Safety Program provides radioactive waste containers upon request, at no cost to the lab. No other containers are permitted to be used unless approved by our program. This reduces the likelihood that radioactive waste will be mistaken for routine, non-regulated trash and disposed of improperly or that the container will leak.

♦ **Survey waste container for contamination.** The Radiation Safety Program must be notified if contamination is found on the outside of waste containers. When requesting a waste pickup, ensure the waste ticket notes that contamination is present. Include the contamination level in the comment section of the waste ticket. Notify the technicians when they come to pick up the container.

♦ **Keep accurate records of the contents of you radioactive waste containers.** Provide the Radiation Safety Program with an accurate estimate of waste activity. Call us if you need assistance with determination of waste activity.

♦ **Never store bulk liquid waste uncapped.**
♦ **Treat bulk liquids to prevent gas formation.** Microorganisms should be killed using bleach or another method. If you plan to combine chemicals that can react to produce excessive heat or gas, consult our program prior to producing the waste.

♦ **Biological material must be packaged to prevent leakage and stored in a freezer prior to pick-up unless prior arrangements have been made with Radiation Safety.** Blood contaminated items should be considered biological waste and packaged accordingly.

♦ **If you use a Plexiglas shielding enclosure, place waste boxes on blue pads outside of the Plexiglas shielding prior to pick up if space permits.** If not, periodically survey the Plexiglas enclosure for contamination.

### INSTRUCTIONS FOR COMPLETING A RADIOACTIVE WASTE TICKET

A Radioactive Waste Ticket must be completed for each container of waste generated. The completed waste ticket must list radionuclides, activity, and waste type as well as other pertinent waste information. Please enter all information. The ticket should be emailed to ehs-radwaste@virginia.edu.

The following information is supplied to assist in completing the waste ticket:

1. **A space for the signature of the individual completing the waste ticket is located at the bottom of the form.** No waste will be picked up if the signature is missing. The signature confirms that the required survey of the waste container surfaces has been completed and verifies that all information on the waste ticket is correct.

2. **Survey the outside of the waste containers before requesting a waste pick-up and record this information on the waste ticket in the space provided.** In accordance with DOT regulations, all radioactive waste containers must be certified free of removable surface contamination exceeding 2,200 dpm/100 cm². Inform the Radiation Safety Program technicians when they arrive to pick up the waste if the survey results are greater than background. Contaminated waste containers will be encapsulated in plastic bags by Radiation Safety Program technicians prior to removal.

A space is provided for reporting the measured pH of bulk liquid samples. The pH must be measured using pH paper or other measuring device. Incorrect pH readings will be investigated by Radiation Safety Program technicians.

### 26.0 Emergency Procedures

Spills of quantities of radioactive material normally present in laboratories at the University present little or no immediate external exposure hazard. Of greater concern is the possibility of internal and external contamination of personnel and the spread of contamination into uncontrolled areas. **Immediate action should be taken to prevent the spread of contamination unless an injured person requires immediate medical attention, volatile radioactive materials are present, or unacceptable external radiation exposure rates exist.**
Radioactive spills during weekdays between 8 am and 5 pm, should be handled in the following manner:

If a radioactive emergency involves a fire, injury or risk to personnel or property, call 911. Radiation Safety Program will be notified.

If there is no fire, injury or risk to personnel or property, confine the spill to the smallest area possible by using paper towels or other absorbent materials and dispose of as radioactive waste. Do not allow spilled radioactive material to enter any floor drains, if possible. Call the Radiation Safety Program at 434-982-4919 for assistance, not 911.

For radioactive spills which occur during evening hours, weekends, or holidays:

Call 911 for the appropriate emergency services in the event of a radioactive emergency that involves fire, injury or risk to personnel or property. Tell the dispatcher that the emergency involves radioactive material. Radiation Safety Program will be notified.

If there is no fire, injury or risk to personnel or property, page the Radiation Safety Program at 923-5047 for assistance, not 911.

Be prepared to give the operator the following information: Lab location and call back phone number(s), radioisotope and activity, a brief description of the incident.

If you remain in the laboratory, keep the call back phone free in case Radiation Safety Program staff needs to contact you. If you must leave the lab, call the Radiation Safety Program from your new location. Only leave the lab if required by the emergency or requested by emergency response personnel.

Minor spills are those which do NOT result in:

- external personnel contamination
- radioactive material ingestion
- unacceptable external radiation exposure
- loss of use of laboratory facilities

1. Notify persons in the area that a spill has occurred.
2. Prevent the spread of contamination by covering the spill with absorbent paper. (Paper should be dampened if solids are spilled).
3. Control access to the spill area as soon as possible by posting warnings on all entrances into the room and by closing off the affected area to prevent the spread of contamination.

4. If there is no external exposure to laboratory personnel (i.e. clothing, shoes), put on protective clothing (e.g. gloves, shoe covers) and clean up the spill. Clean up the spill using absorbent paper. If you are unsure how to properly clean up the spill, call the Radiation Safety Program as soon as possible for assistance. Radiation Safety Program staff can offer consultation, equipment and assistance.

5. Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Put contaminated gloves and any other contaminated disposable material in the bag and then call the Radiation Safety Program to report the incident.

6. If there is radioactive contamination on clothing, shoes, or personnel, call the Radiation Safety Program for assistance as soon as possible. Potentially contaminated personnel must not leave the area until they have been surveyed by either Radiation Safety Program staff or trained laboratory personnel.

7. If radioactive material goes down a floor drain or spills out of the authorized room into unauthorized areas, call the Radiation Safety Program as soon as possible for assistance.

8. Survey the area with an appropriate low-range radiation detector survey meter or other appropriate technique. Check the area around the spill for contamination. Also check hands, clothing, and shoes for contamination. All clean-up surveys must be documented in your Laboratory Survey Records.

9. Allow no one to return to work in the area unless approved by the RSO. A written report must be submitted to the RSO within five (5) working days of the incident for all spills that involve contaminated personnel or involve unauthorized areas.

10. Cooperate with the RSO and Radiation Safety Program staff (e.g., investigation of root cause, provision of requested bioassay samples). Follow the instructions of the RSO and the Radiation Safety Program staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

**Major spills of liquids or solids** are those that result in:

- external personnel contamination
- radioactive material ingestion
- unacceptable external radiation exposure
- loss of use of laboratory facilities

1. Notify other personnel in the room where the spill occurs.

2. Clear the area. If appropriate, survey all persons not involved in the spill and vacate the room.

3. Prevent the spread of contamination by covering the spill with absorbent paper (paper should be dampened, if solids are spilled), but do not attempt to clean it
up. To prevent the spread of contamination, limit the movement of all personnel who may be contaminated.

4. Shield the source only if it can be done without further contamination or significant increase in radiation exposure.

5. Close the room and lock or otherwise secure the area to prevent entry. Post the room with a sign to warn anyone trying to enter that a spill of radioactive material has occurred. Stay in the immediate vicinity of the affected room to prevent the spread of contamination and provide the Radiation Safety Program with information and assistance. Control access to the spill area as soon as possible by posting warnings on all entrances to the room and by barricading the affected area to prevent the spread of contamination.

5. Notify the Radiation Safety Program immediately. Radiation Safety Program staff will assist you in planning the decontamination procedures.

6. Survey all personnel who could possibly have been contaminated. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and then washing with a mild soap. Begin personnel surveys to determine if individuals are contaminated. Assume that all persons in the affected area may be contaminated. Do not allow anyone to leave the immediate vicinity until Radiation Safety Program staff has confirmed the results of your preliminary surveys.

7. Allow no one to return to work in the area unless approved by the RSO. Radiation Safety Program staff will control access to all areas where the exposure rate is greater than 2 mR/hr. Your detector must be calibrated in units of mR/hr to obtain a measurement in mR/hr; most UVa survey instruments are calibrated in units of CPM. The Radiation Safety Program maintains instruments calibrated to perform exposure rate measurements (mR/hr).

8. With permission and possible assistance by Radiation Safety Program staff, put on protective clothing provided by EHS and begin decontamination and cleanup.

9. All clean-up surveys must be documented in your Laboratory Survey Records.

10. A written report must be submitted to the RSO within five (5) working days of the incident for all spills that involve contaminated personnel or involve unauthorized areas.

11. Cooperate with the RSO and the Radiation Safety Program staff (e.g., investigation of root cause, provision of requested bioassay samples). Follow the instructions of the RSO and the Radiation Safety Program staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

Incidents Involving Radioactive Dusts, Mists, Fumes, Organic Vapors, and Gases

1. Notify all personnel to vacate the room immediately.

2. Shut down ventilation system, if possible, unless it is determined that the room ventilation system needs to be used to clear the air for access purposes.

3. Vacate the room. Seal the area, if possible.
5. Ensure that all access doors to the area are closed and posted with radiation warning signs, or post guards (trained) at all access doors to prevent accidental opening of the doors or entry to the area.
6. Survey all persons who could have possibly been contaminated. Decontaminate as directed by the RSO or Radiation Safety Program staff.
7. Promptly report suspected inhalations and ingestions of licensed material to the Radiation Safety Program.
8. Decontaminate the area only when advised and/or supervised by the RSO or Radiation Safety Program staff.
9. Allow no one to return to work in the area unless approved by the RSO or Radiation Safety Program staff.
10. Cooperate with the RSO and Radiation Safety Program staff (e.g., investigation of root cause, provision of requested bioassay samples). Follow the instructions of the RSO and Radiation Safety Program staff (e.g., decontamination techniques, surveys, provision and collection of bioassay samples, requested documentation).

**Minor Fires**

1. Immediately attempt to put out the fire by approved methods (e.g., fire extinguisher) if other fire hazards or radiation hazards are not present.
2. Notify all persons present to vacate the area and have one individual immediately call the Radiation Safety Program and fire department (as instructed by RSO).
3. Once the fire is out, isolate the area to prevent the spread of possible contamination.
4. Survey all persons involved in combating the fire for possible contamination.
5. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water, then washing with a mild soap.
6. In consultation with the RSO or Radiation Safety Program staff, determine a plan of decontamination and the types of protective devices and survey equipment that will be necessary to decontaminate the area.
7. Allow no one to return to work in the area unless approved by the RSO or Radiation Safety Program staff.
8. Cooperate with the RSO and Radiation Safety Program staff (e.g., investigation of root cause, provision of requested bioassay samples). Follow the instructions of the RSO and Radiation Safety Program staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

**Fires, Explosions, or Major Emergencies**

1. Notify all persons in the area to leave immediately.
2. Call 911
4. Upon arrival of firefighters, inform them where radioactive materials are stored or where radioisotopes were being used; inform them of the present location of the licensed material and the best possible entrance route to the radiation area,
as well as any precautions to avoid exposure or risk of creating radioactive contamination by use of high-pressure water, etc.

5. Cooperate with the RSO and Radiation Safety Program staff (e.g., investigation of root cause, provision of requested bioassay samples).

6. Allow no one to return to work in the area unless approved by the RSO or Radiation Safety Program staff. Follow the instructions of the RSO and Radiation Safety Program staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

27.0 Laboratory and Equipment Decommissioning

Decontamination is the cleaning and removal of radioactive contamination from equipment and surfaces. Decommissioning is the process of ensuring that all contamination and radioactive material is removed from the area(s) where it was used. Decommissioning also entails the removal of all signs, postings, radioactive material tape, and performance of final swipe surveys that ensure that all equipment and surfaces are free of contamination. An area or piece of equipment must be decontaminated and decommissioned before it is released for unrestricted use.

27.1 Laboratory Decommissioning

If a lab will no longer to be used as a radioactive material use area, it must be formally decommissioned by Radiation Safety Program technicians. Please call the Radiation Safety Program to arrange for a lab decommissioning. Under no circumstance shall a lab be vacated, renovated or used by others without proper decommissioning.

27.2 Decommissioning Records

All laboratories and other material use or storage areas are decommissioned in accordance with Radiation Safety Program policies and procedures. The Radiation Safety Program must maintain records of all decommissioned rooms and material use areas.

27.3 Release of Equipment for Unrestricted Use

Any piece of equipment (e.g. centrifuge, HPLC, LSC and similar equipment) that was used for the manipulation or handling of radioactive material must be decontaminated to a level at which any remaining contamination cannot be distinguished from background radiation. A Radiation Safety Program technician will verify adequate decontamination prior to its release for unrestricted use. If you anticipate the need to have equipment decontaminated for use in a non-radioactive area, call the Radiation Safety Program for assistance. Under no circumstance shall any equipment be abandoned, sent to surplus or transferred without proper decommissioning.

27.4 Release of Equipment to Surplus
Large pieces of equipment (refrigerators, centrifuges, incubators, etc.) that are no longer needed must be decommissioned by Radiation Safety Program technicians. Do not send equipment used for radioactive work to surplus or trash unless they have been surveyed by Radiation Safety Program technicians. **Do NOT remove any radioactive signs or stickers from items before they have been decommissioned.** All radioactive labels and or sources must be removed by Radiation Safety Program staff after decommissioning and prior to disposal or transfer to surplus. Certain scintillation counters have internal radioactive sources that must be removed prior to disposal.

### 27.5 Important Points to Remember

- Lab areas and equipment cannot be abandoned without prior decommissioning.
- Laboratory personnel are responsible for the decontamination and general cleanup of the lab.
- Signs related to radiation and radioactive material can only be posted and removed by Radiation Safety personnel.
- The PI/AU is responsible for the lab area until the final decommissioning survey has been performed by Radiation Safety Program technicians.
# 28.0 Nuclide Safety Data Sheets

<table>
<thead>
<tr>
<th>Nuclide Safety Data Sheet</th>
<th>Hydrogen-3 [Tritium]</th>
<th>3H</th>
</tr>
</thead>
</table>

## I. PHYSICAL DATA

| Radiation: | Beta (100% abundance) |
| Energy: | Max.: 18.6 keV; Average: 5.7 keV |
| Half-Life \[T_{1/2}\]: | Physical \[T_{1/2}\]: 12.3 years |
| | Biological \[T_{1/2}\]: 10 - 12 days |
| | Effective \[T_{1/2}\]: 10 - 12 days* |

* Large liquid intake (3-4 liters/day) reduces effective \[T_{1/2}\] by a factor of 2+; ³H is easily flushed from the body.

| Specific Activity: | 9850 Ci/g [357 TBq/g] max. |
| Beta Range: | Air: 6 mm [0.6 cm; 0.25 inches] |
| | Water: 0.006 mm [0.0006 cm; 3/10,000 inches] |
| Solids/Tissue: insignificant [No ³H betas pass through the dead layer of skin] |

## II. RADIOLOGICAL DATA

| Radiotoxicity¹ | Least radiotoxic of all nuclides; CEDE, ingestion or inhalation: |
| | Tritiated water: 1.73E-11 Sv/Bq (0.064 mrem/μCi) of ³H intake |
| | Organic Compounds: 4.23E-11 Sv/Bq (0.16 mrem/μCi) of ³H intake |
| Critical Organ: | Body water or tissue |
| Exposure Routes: | ingestion, inhalation, puncture, wound, skin contamination absorption |
| Radiological Hazard: | External Exposure - None from weak ³H beta |
| | Internal Exposure & Contamination - Primary concern |

## III. SHIELDING

None required - not an external radiation hazard

## IV. DOSIMETRY MONITORING

Urine bioassay is the only readily available method to assess intake [for tritium; no intake = no dose]. Be sure to provide a urine sample to Radiation Safety whenever your monthly ³H use exceeds 100 mCi, or after any accident/incident in which an intake is suspected.

## V. DETECTION & MEASUREMENT

Liquid Scintillation Counting is the only readily available method for detecting ³H.

**NOTE:** PORTABLE SURVEY METERS WILL NOT DETECT LABORATORY QUANTITIES OF ³H

## VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many tritium compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.
- While tritiated DNA precursors are considered more toxic than ³H₂O, they are generally less volatile and hence do not normally present a greater hazard.
- The inability of direct-reading instruments to detect tritium and the slight permeability of most material to [tritiated] water & hydrogen [tritium] facilitates undetected spread of contamination. Use extreme care in handling and storage [e.g. sealed double or multiple containment] to avoid contamination, especially with high specific activity compounds.

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VII. GENERAL PRECAUTIONS
1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES
1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheathing (i.e., painter's drop cloth), periodically wipe it clean and replace if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. \(^{35}\)S labeled amino acids, \(^{125}\)I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms. Notify Radiation Safety staff before taking any radioactive material off site.
I. PHYSICAL DATA

- Radiation: Beta (100% abundance)
- Energy: Max.: 156 keV; Average: 49 keV
- Half-Life [T½]:
  - Physical T½: 5730 years
  - Biological T½: 12 days
  - Effective T½: Bound - 12 days; unbound - 40 days
- Specific Activity: 4.46 Ci/g [0.165 TBq/g] max.
- Beta Range:
  - Air: 24 cm [10 inches]
  - Water/Tissue: 0.28 mm [0.012 inches]
  - [-1% of 14C betas transmitted through dead skin layer, i.e. 0.007 cm depth]
  - Plastic: 0.25 mm [0.010 inches]

II. RADIOLOGICAL DATA

- Radiotoxicity: 6.36E-12 Sv/Bq [0.023 mrem/µCi] of 14CO₂ inhaled;
  5.64E-10 Sv/Bq [0.09 mrem/µCi] organic compounds inhaled/ingested
- Critical Organ: Fat tissue [most labeled compounds]; bone [some labeled carbonates]
- Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption
- Radiological Hazard: External Exposure - None from weak 14C beta
  Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for 14C, no intake = no dose]
Provide a urine sample to Radiation Safety whenever your monthly 14C use exceeds 5 mCi, or after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM, ~10% efficiency];
Beta Scintillator [e.g. Ludlum 44-21, ~5% efficiency]
Wipe Test: Liquid Scintillation Counting is the best readily available method for counting 14C wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many 14C compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.

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VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab that staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend “radioactive”. Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it’s contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter’s drop cloth), periodically wipe it clean and replace if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [Inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled “Caution Radioactive Material”.
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g., $^{35}$S labeled amino acids, $^{125}$I - iodine tends to volatilizes in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms. Notify Radiation Safety staff before taking any radioactive material off site.
I. PHYSICAL DATA

Radiation: Beta (100% abundance)
Energy: Maximum: 1,710 keV; Average: 695 keV
Half-Life [T1/2]:
  Physical T1/2: 14.29 days
  Biological T1/2: Bone – 1155 days; Whole Body – 257 days
Effective T1/2: 14.29 days
Specific Activity: 286,500 Ci/g [10,600 TBq/g] max.
Beta Range:
  Air: 610 cm [240 inches; 20 feet]
  Water/Tissue: 0.76 cm [0.33 inches]
  Plastic: 0.61 mm [3/8 inches]

II. RADIOLOGICAL DATA

Radiotoxicity:
  Inhaled: 2.6E-8 Sv/Bq [95 mrem/uCi] Lung; 4.2E-9 Sv/Bq [16 mrem/uCi] CEDE
  Ingested: 8.1E-9 Sv/Bq [30 mrem/uCi] Marrow; 2.4E-9 Sv/Bq [8.8 mrem/uCi] CEDE
Critical Organ: Bone [soluble 32P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]
Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard: External Exposure [unshielded dose rate at 1 mCi 32P vial mouth: approx. 26 rem/hr]; Internal Exposure & Contamination

III. SHIELDING

Shield 32P with 3/8 inch Plexiglas and monitor for Bremsstrahlung; If Bremsstrahlung X-rays detected outside Plexiglas, apply 1/8 to 1/4 inch lead [Pb] shielding outside Plexiglas
The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Always wear radiation dosimetry monitoring badges [body & ring] whenever handling 32P

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM]; Beta Scintillator [e.g. Ludlum 44-21]
Wipe Test: Liquid Scintillation Counting is an acceptable method for counting 32P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Store 32P (including waste) behind Plexiglas shielding [3/8 inch thick]; survey [with GM meter] to check adequacy of shielding (accessible dose rate < 2 mR/hr; should be background); apply lead [Pb] shielding outside Plexiglas if needed
- Use 3/8 inch Plexiglas shielding to minimize exposure while handling 32P
- Use tools [e.g. Beta Blocks] to handle 32P sources and contaminated objects; avoid direct hand contact
- Always have a portable survey meter present and turned on when handling 32P
- 32P is not volatile, even when heated, and can be ignored as an airborne contaminant unless aerosolized
- White vinegar can be an effective decontamination solvent for this nuclide in most forms

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1. NCRP Report No. 65, p.88
VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable (ALARA).
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff are not permitted to pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheathing (i.e., painter's drop cloth), periodically wipe it clean and replace if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g., 35S labeled amino acids, 125I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms. Notify Radiation Safety staff before taking any radioactive material off site.
I. PHYSICAL DATA

Radiation: Beta (100% abundance)
Energy: Maximum: 167.47 keV; Average: 48.8 keV
Half-Life [T1/2]:
  Physical T1/2: 87.44 days
  Biological T1/2: 623 days [unbound 35S]; 90 days [bound 35S]
  Effective T1/2: 44 - 76 days [unbound 35S]
Specific Activity: 42,707 Ci/g [1,580 TBq/g] max
Beta Range:
  Air: 26 cm [10.2 inches]
  Water/Tissue: 0.32 mm [0.015 inches]
  Plastic: 0.25 mm [0.010 inches]

II. RADIOLOGICAL DATA

Radiotoxicity:
  2.48 mrem/uCi (CEDE) of 35S inhaled
  0.733 mrem/uCi of 35S ingested
Critical Organ: Testis
Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:
  External Exposure - None from weak 35S beta
  Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for 35S, no intake = no dose]
Provide a urine sample to Radiation Safety whenever your monthly 35S use exceeds 5 mCi, or after
any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Portable Survey Meters:
  Geiger-Mueller [e.g. Bicron PGM, ~10% efficiency]
  Beta Scintillator [e.g. Ludlum 44-21, ~5% efficiency]
Wipe Test: Liquid Scintillation Counting is the best readily available method for counting 35S wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many 35S compounds and metabolites are slightly volatile and may create contamination problems if
  not sealed or otherwise controlled. This occurs particularly when 35S amino acids are thawed, and
  when they are added to cell culture media and incubated. Therefore vent thawing 35S vials in a hood
  by inserting the needle of a charcoal packed syringe through the septum seal, and vent incubated
  35S-labelled tissue culture through charcoal-impregnated filter paper.

1 Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156
VII. GENERAL PRECAUTIONS

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4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods.
   The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. 35S labeled amino acids, 125I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.
I. PHYSICAL DATA

Radiation: Beta (100% abundance)
Energy: Maximum: 246.5 keV; Average: 76.4 keV
Half-Life [T½]: Physical T½: 25.3 days
          Biological T½: Bone ~ 1155 days; Whole Body ~ 257 days
          Effective T½: 25.3 days
Specific Activity: 156,000 Ci/g [5,780 TBq/g] max.
Beta Range:
          Air: 50 cm (~20 inches)
          Water/Tissue: 0.06 cm [0.024 inches]
          Plastic: 0.05 cm [0.02 inches]

II. RADIOLOGICAL DATA

Radiotoxicity:\ 15.6 mrem/µCi (Lung) & 2.32 mrem/µCi [CEDE] of 32P inhaled
1.85 mrem/µCi [Bone Marrow] & 0.92 mrem/µCi [CEDE] of 32P ingested
Critical Organ: Bone [soluble 32P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]
Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard: External Exposure - mCi quantities not considered an external hazard
          Internal Exposure & Contamination - Primary concern

III. SHIELING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for 32P, no intake = no dose].
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected.
No dosimetry badges needed when working with 32P [beta energy too low to be detected]

V. DETECTION & MEASUREMENT

Portable Survey Meters:
          Geiger-Mueller [e.g. Bicron PGM]
          Beta Scintillator [e.g. Ludlum 44-21]
Wipe Test: Liquid Scintillation Counting works well for counting 32P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- 32P is not volatile, even when heated, and can be ignored as an airborne contaminant3 unless aerosolized.
- White wine vinegar can be an effective decontamination solvent for this nuclide in most common chemical forms.

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1 NCRP Report No. 65, p.88
VII. GENERAL PRECAUTIONS

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5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
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7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. 35S labeled amino acids, 125I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms. Notify Radiation Safety staff before taking any radioactive material off site.
I. PHYSICAL DATA

 Radiation:  Gamma - 320 keV (9.8% abundance)
            X-ray - 5 keV (22% abundance)

 Gamma Constant:  0.023 mR/hr per mCi @ 1.0 meter [6.32E-6 mSv/hr per MBq @ 1.0 meter]

 Half-Life [T½]:  Physical T½: 27.7 days
                   Biological 616 days
                   Effective T½: 26.6 days (whole body)

 Specific Activity:  9.24E4 Ci/g  [3.42E3 TBq/g] max.

II. RADIOLOGICAL DATA

 Radiotoxicity:  0.145 mrem/uCi of 51Cr ingested [CEDE]
                0.334 mrem/uCi of 51Cr inhaled [CEDE]

 Critical Organ:  Lower Large Intestine [LLI]

 Intake Routes:  Ingestion, inhalation, puncture, wound, skin contamination (absorption);

 Radiological Hazard:  External & Internal Exposure; Contamination

III. SHIELDING

<table>
<thead>
<tr>
<th>Material</th>
<th>Half Value Layer (HVL)</th>
<th>Tenth Value Layer (TVL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead [Pb]</td>
<td>2 mm (0.07 inches)</td>
<td>6.6 mm (0.23 inches)</td>
</tr>
<tr>
<td>Concrete</td>
<td>2.8 cm (1.1 inches)</td>
<td>9.3 cm (3.7 inches)</td>
</tr>
<tr>
<td>Plexiglas</td>
<td>4.8 cm (1.9 inches)</td>
<td>16 cm (6.3 inches)</td>
</tr>
</tbody>
</table>

The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Always wear radiation dosimetry monitoring badges [body & ring] whenever handling 51Cr

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness

Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys

Wipe Test: Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Store 51Cr (including waste) behind lead shielding [1/4 - 1/2 inch thick]; survey (with GM meter) to check adequacy of shielding (accessible dose rate < 2 mR/hr; should be background)
- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Use shielding to minimize exposure while handling 51Cr
- Use tools to handle 51Cr sources and contaminated objects; avoid direct hand contact

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1 Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD, Williams & Wilkins, 1998], p. 6-9
VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend “radioactive”. Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it’s contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter’s drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled “Caution Radioactive Material”.
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. $^{35}$S labeled amino acids, $^{125}$I - iodine tends to volatilize in acidic solutions]. Those precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

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I. PHYSICAL DATA

Radiation: Gamma: 141 keV (89% abundance)
X-rays: 18 keV (6% abundance), 21 keV (1.2% abundance)

Gamma Constant: 0.77 R/hr at 1 cm from an unshielded 1 mCi point source

Half-Life [T1/2]: Physical T1/2: ~ 6.0 hours
Biological T1/2: ~ 1 day
Effective T1/2: ~ 4.8 hours

Specific Activity: 5.27E6 Ci/g [1.95E17 Bq/g]

II. RADIOLOGICAL DATA

Radiotoxicity: 0.062 mrem/mCi [1.68E-11 Sv/Bq] of 99mTc ingested [CEDE]²
0.27 mrem/mCi [7.21E-11 Sv/Bq] of 99mTc inhaled [CEDE]³

Critical Organ: Thyroid Gland; Upper GI tract

Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption

Radiological Hazard: External & Internal Exposure; Contamination

III. SHIELDING

<table>
<thead>
<tr>
<th>Half Value Layer (HVL)</th>
<th>Tenth Value Layer (TVL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 mm</td>
<td>1 mm</td>
</tr>
</tbody>
</table>

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling 99mTc
- Submit a urine sample to Radiation Safety two to 24 hours [i.e. As Soon As Possible] after any suspected intake of 99mTc; alert Radiation Safety of the short half-lived nuclide involved.

V. DETECTION & MEASUREMENT

- Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness
- Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys

- Wipe Test: Gamma Counter, Well Gamma Counter, or Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Store 99mTc behind ½-inch [~ 0.6 cm] thick lead (Pb) shielding
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact
- Ensure that an appropriate, operational survey meter (e.g. Bicron PGM) is present in the work area and turned on whenever 99mTc is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed
- Shield waste containers as needed to maintain accessible dose rate ALARA and < 2 mR/hr

¹ Dupont/NEN, Technetium-99m Handling Precautions (Boston, MA: NEN, 1985)
VII. GENERAL PRECAUTIONS
1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES
1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
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3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. 35S labeled amino acids, 125I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.
I. PHYSICAL DATA
Radiation: Gamma - 35.5 keV (7% abundance)
          X-ray - 27 keV (113% abundance)
Gamma Constant: 0.27 mR/hr per mCi @ 1.0 meter [7.432E-5 mSv/hr per MBq @ 1.0 meter]¹
Half-Life [T₁/₂]:
          Physical T₁/₂: 60.14 days
          Biological T₁/₂: 120-138 days (unbound iodine)
          Effective T₁/₂: 42 days (unbound iodine)
Specific Activity: 1.73E4 Ci/g [642 TBq/g] max

II. RADIOLOGICAL DATA
Radiotoxicity: 3.44E-7 Sv/Bq (1273 mrem/µCi) of ¹²⁵I ingested [Thyroid]
               2.16 E-7 Sv/Bq (799 mrem/µCi) of ¹²⁵I inhaled [Thyroid]
Critical Organ: Thyroid Gland
Intake Routes: Ingestion, inhalation, puncture, wound, skin contamination (absorption);
              External & Internal Exposure; Contamination

III. SHIELDING
          Half Value Layer [HVL]  Tenth Value Layer [TVL]
          Lead [Pb]  0.02 mm (0.0008 inches)  0.07 mm (0.003 inches)
          → The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING
• Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ¹²⁵I
• Conduct a baseline thyroid scan prior to first use of radioactive iodine
• Conduct thyroid scan no earlier than 6 hours but within 72 hours of handling 1 mCi or more of ¹²⁵I or
  after any suspected intake

V. DETECTION & MEASUREMENT
Portable Survey Meters:
          Geiger-Mueller [e.g. Bicron PGM, ] to assess shielding effectiveness
          Low Energy Gamma Detector [e.g. Ludlum 44-21, ~19% eff. for ¹²⁵I] for contamination surveys
Wipe Test:
          Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS
• Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
• Use shielding [lead or leaded Plexiglas] to minimize exposure while handling mCi quantities of ¹²⁵I
• Avoid making low pH [acidic] solutions containing ¹²⁵I to avoid volatilization
• For iodinations:
  - Use a cannula adapter needle to vent stock vials of ¹²⁵I used; this prevents puff releases
  - Cover test tubes used to count or separate fractions from iodinations with parafilm or other
    tight caps to prevent release while counting or moving outside the fume hood.

¹ Health Physics & Radiological Health Handbook. 3rd Ed. [Baltimore, MD: Williams & Wilkins, 1998], p. 6-11
VII. GENERAL PRECAUTIONS

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5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following DU/DUMC Waste Handling & Disposal Procedures - http://www.safety.duke.edu/EnviroPrograms/Radiopro.htm. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff are not permitted to pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety at 684-2194.

VIII. LAB PRACTICES

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