

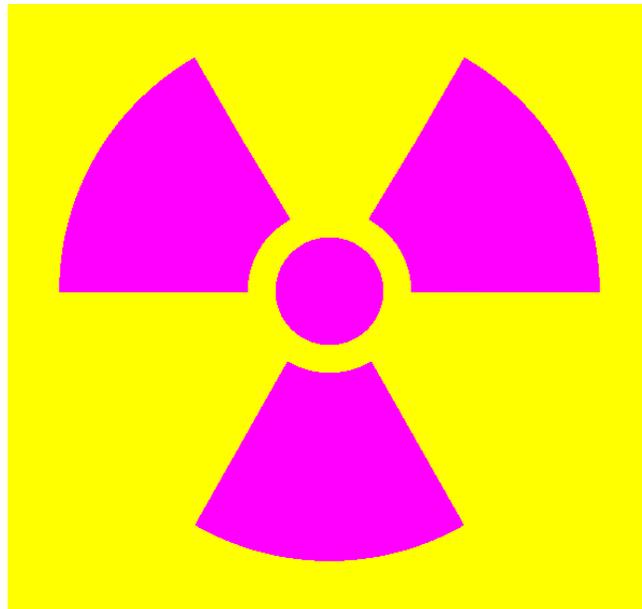


MACON & JOAN BROCK VIRGINIA HEALTH SCIENCES

**Environmental Health & Safety**

AT OLD DOMINION UNIVERSITY

# RADIATION SAFETY MANUAL



2025

Approved by the VHS Radiation Safety Committee members during the April 11, 2025, meeting.

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## **FOREWORD**

This Radiation Safety Manual represents one part of the Macon & Joan Brock Virginia Health Sciences at Old Dominion University (VHS) administration's commitment to keeping occupational radiation exposures as low as reasonably achievable (ALARA). While radiation exposure to patients in the healing arts has demonstrated a sizeable benefit-to-risk ratio for both diagnosis and therapy, physicians, scientists, and regulatory agencies widely agree that occupational exposures should be minimized as far as is practical.

VHS has created, staffed, and equipped a Radiation Safety Office within Environmental Health and Safety (EH&S) to oversee the use of radioactive material in research and occupational exposures. VHS is committed to adequately training investigators using radioactive material and supporting the staff of the Radiation Safety Office in their efforts to ensure compliance with regulations and to keep radiation exposures ALARA.

The administration welcomes input from radiation workers about our radiation safety program. Modifications to operating and maintenance procedures, equipment, and facilities will be considered where they will substantially reduce radiation exposure at a reasonable cost.

## **INTRODUCTION**

Radioactive materials and radiation-producing machines must be used to minimize radiation exposure to personnel and the environment. VHS operates within regulations issued by the Commonwealth of Virginia (Radiation Protection Regulations, Chapter 481 of the Virginia Administrative Code). These regulations constitute minimum requirements for maintaining a safe and productive workplace. The policy of VHS is to keep radiation exposure ALARA.

Strict adherence to this manual will help ensure safety for those using radioactive material or radiation-producing machines. Failure to employ safe practices and procedures could result in excessive personnel or environmental exposure and jeopardize institutional licenses.

The VHS Radiation Safety Committee (RSC) issues this Radiation Safety Manual. All personnel using radiation sources must be familiar with its requirements and conduct their operations within its framework. Comments or recommendations concerning its contents should be submitted to the Radiation Safety Office.

## **1. ORGANIZATIONAL STRUCTURE**

Below is the organizational and administrative structure for supervising the possession and use of radiation sources at the medical campus, which is part of the ODU campus. See sections 2, 3, 4, and 6 for details.

- Macon & Joan Brock Virginia Health Sciences at Old Dominion University
  - Eastern Virginia Medical School
    - Dean of the Medical School
      - **EVMS Radiation Safety Committee**
- President, Old Dominion University
  - Executive Vice President, Health Sciences
    - Senior Associate Vice President, Administration & Finance, Chief Financial Officer
      - Executive Director, Risk Management
        - **RSO & Director Environmental Health & Safety 2**

## **2. RADIATION SAFETY COMMITTEE**

### **a) General Description**

The RSC shall be a standing committee of the institution. The Dean shall appoint the RSC and consist of at least the Senior Associate Dean for Research (Administrative Representative), the Radiation Safety Officer (RSO), and one or more faculty members working with or having experience with radioactive material. The Senior Associate Dean for Research and the RSO are not eligible to serve as permanent Chairman of the Committee. The RSC shall meet at least quarterly and upon the call of the Chairman. A quorum shall consist of three members: the Chairman or Vice Chairman, the Radiation Safety Officer or alternate, and the Administrative Representative or alternate.

The application to use radioactive material is made on forms for the RSC. The Chairman and the RSO review the applications. The RSC is solely responsible for possessing and using radioactive materials and radiation sources. The RSC is the final authority within VHS in all matters related to establishing and administrating the Radiation Safety program. This Committee has been designated by the Virginia Department of Health, Division of Radiological Health, as the responsible agent for VHS. The curriculum vitae for RSC members shall be kept on file by the Radiation Safety Office.

### **b) Duties and Functions**

The duties and functions of the RSC are to:

- i. Establish rules, regulations, policies, and guidance regarding VHS radiation safety and radiation-producing machines.
- ii. Review and act upon all applications for possession and use of radionuclides or radiation-producing machines.
- iii. Establish procedures to ensure adequate personnel and environmental protection for persons working with radioactive material and radiation-producing machines.
- iv. Review and approve program procedural changes before implementation.
- v. Annually review the Radiation Safety program, activities of the RSO, and records that must be maintained to ensure compliance with conditions of licenses with the Commonwealth of Virginia and federal and state regulations.
- vi. Receive and review periodic reports from the Radiation Safety Officer.
- vii. Review instances of non-compliance with procedures for using radioactive materials or safety rules established by the Radiation Safety Office. The review will include an analysis of the cause, corrective actions, and actions to prevent recurrence.
- viii. Report annually to the VHS President, Provost, and Dean.

c) **Responsibility of Chairman**

It shall be the responsibility of the Chairman to:

- i. Report periodically the actions of the RSC to the Dean or their designate.
- ii. Call for meetings of the RSC.
- iii. Minutes of the RSC meetings shall be circulated to other committees responsible for biosafety or hazardous chemicals, and coordination should be established with other responsible committees, such as the Institutional Review Board (IRB), Institutional Biosafety Committee (IBC), and Institutional Animal Care and Use Committee (IACUC).
- iv. Appoint subcommittees to deal with specific areas of radiation as needed.
- v. Vote in Committee matters.
- vi. Inform RSC members of their duties, functions, and responsibilities.

### **3. RADIATION SAFETY OFFICER**

#### **a) General**

The Radiation Safety Officer (RSO) is appointed by the authority of the President, Provost, and Dean of VHS and who, because of education, training, and experience, is qualified to advise others in the safe use of radiation. He/she shall be a member of the administration and the Radiation Safety Committee. The primary mission of the RSO is to execute the policies established by the RSC and to ensure compliance with Federal and State regulations.

The Radiation Safety Committee policy is that the Radiation Safety Officer and other radiation safety personnel provide radiation protection services to the VHS community. This service extends from health and safety functions through legal and administration duties to procuring, using, and disposing of radioactive materials and other radiation sources. A *Radiation Safety Office* is established to provide these services.

The Radiation Safety Officer reports to the Old Dominion University Executive Director of Risk Management for administrative purposes and to the Radiation Safety Committee for matters on institutional radiation safety.

#### **b) Responsibilities**

The Radiation Safety Officer is responsible for:

- i. Monitoring and surveys of all areas in which radioactive material is used.
- ii. Oversight of ordering, receipt, surveys, and delivery of byproduct material. Monitoring and maintaining systems associated with using, storing, or disposing of radioactive material.
- iii. Packaging, labeling, surveys, etc., of all shipments of radioactive material leaving the licensed facilities.
- iv. A personnel monitoring program includes determining the need for and evaluating bioassays, monitoring personnel exposure records, and developing corrective actions for reducing exposures.
- v. Training authorized, qualified, and restricted users and ancillary personnel.
- vi. Radioactive waste disposal program.
- vii. Inventory and leak tests of sealed sources.
- viii. Decontamination
- ix. Investigating any incidents and responding to any emergencies involving radioactive material.
- x. Maintaining all required records.

c) **Additional Functions**

The Radiation Safety Officer will provide a:

- i. Semi-annual report on the inventory of radioactive materials at VHS.
- ii. Report at every quarterly meeting of the RSC of unusual or abnormal incidents involving radiation and radioactive material.

d) **Authority**

The Radiation Safety Officer has the authority to immediately terminate a project, activity, or use of radiation or radioactive material that is found to be a threat to health or property. This would include closing a laboratory or confiscating radioactive material if such actions would remove or prevent the recurrence of a danger to health or property. Any such action by the RSO must be reported in writing to the Chairman of the RSC within 48 hours.

## **4. DEFINITION OF USERS**

### **a) General**

The Radiation Safety Committee (RSC) is empowered to authorize the possession and use of radioactive materials and radiation-producing machines. Several categories of users have been established for which an individual may apply. These are

- Authorized User
- Qualified User
- Restricted User

Individual users and the RSC share responsibility for safely using radioactive material and radiation-producing machines. This chain is independent of other administrative lines of control within VHS. However, the RSC recognizes the right of any administrative entity within VHS to impose additional restrictions, qualifications, and regulations regarding the use of radioactive material, radiation, or equipment by persons under its control.

The responsibilities of radionuclide users are outlined in Section 6, and the procedures an individual must follow to become a user are presented in Section 5 of this manual.

### **b) Authorized User**

A person designated by the RSC as an "Authorized User" may possess and use radioactive materials and/or radiation-producing machines as specified in their permit from the RSC. An Authorized User is responsible for properly storing materials under their control and for proper use under their direction. An Authorized User may initiate the purchase or transfer of radioactive materials as described in this manual.

In general, Authorized Users shall be permanent members of VHS with significant training and experience in using radioactive materials. They should hold a position that allows them to administer the use of radioactive materials under their authorization. An Authorized User may sponsor the use of radioactive materials and radiation-producing machines by Qualified Users and personally supervise Restricted Users.

### **c) Qualified User**

The "Qualified User" category allows individuals to use radioactive material or radiation-producing machines in specific circumstances under the sponsorship of an Authorized User. The Authorized User shall bear primary responsibility for training the Qualified User in laboratory procedures using radioactivity and for the safe use and storage of the material. The Qualified User category is intended for students or technical employees with adequate training and experience in using radioactive material whose association with VHS may not be permanent and whose background may not be extensive enough to warrant a broad authorization to use radioactive materials or radiation-producing machines. The Qualified User works under the supervision of an Authorized User and may independently use radioactive material in protocols approved by the Authorized User permit.

d) **Restricted User**

A "Restricted User" has not received authorization by the RSC as either an Authorized or Qualified User. Generally, a Restricted User has had prior training and experience working with radioactivity but hasn't completed radiation safety training at VHS. A Restricted User may only use radioactive materials or radiation-producing machines under the DIRECT SUPERVISION of an Authorized User. Authorized Users shall notify the RSO in writing when an individual works for them as a Restricted User. The memo should include the Restricted User's name and the date they became a Restricted User.

e) **Direct or Personal Supervision**

- i. Direct supervision requires that the Authorized User to plan the operation. The Restricted User has been informed of potential hazards and instructed in procedures to be followed in normal circumstances and in the *event of an abnormal occurrence or accident*.
- ii. When the operation involves unsealed sources of radioactive material, the Authorized User must remain in the immediate area while the radionuclide is in use.
- iii. When the operation involves a sealed source or sources that do not present dose rates at the accessible boundary of the restricted area exceeding 2.0 mrem/hr, the Authorized User need not remain in the room. However, the Authorized User must be in the same general area of the building where the radionuclide is in use and be aware of the operation in progress.

## **5. APPLICATION PROCEDURES AND GENERAL CRITERIA FOR APPROVAL**

### **a) General**

Application for possession and use of sources of radiation and for Authorized User or Qualified User Status will be made using the appropriate hard copy or electronic forms available from the Radiation Safety Office.

The application procedure has two parts: "Training and Experience" (RSO-1, "Application for User Status") and "Possession and Use" (RSO-2, "Application for Possession and Use" and/or RSO-4, "Application for Radiation Device"). The "Possession and Use" application must be renewed every two years, while the "Training and Experience" application is only needed initially *or when significant changes occur*.

### **b) Application Submission**

Applications will be submitted to the RSO for preliminary review. The RSO will coordinate the review with the RSC Chairman. Review and approval will ordinarily be done between regularly scheduled meetings by email and telephone.

### **c) Approval Criteria**

Applications may be approved if the RSC is satisfied that the applicant:

- i. Has adequate training and experience to conduct the proposed use safely.
- ii. Possesses sufficient facilities and equipment (including shielding, containment, and survey instruments) appropriate for the proposed use.
- iii. Has safe and effective operating, handling, survey, security, accountability, and emergency procedures.
- iv. Conforms to all applicable procedures and regulations regarding safe use of radionuclides.

### **d) Authorization**

When approved by the Radiation Safety Committee, a copy of the application will be appropriately marked and returned to the applicant to serve as their permit.

### **e) Renewal or Amending the Authorization**

Permit renewal is accomplished by submitting an RSO-3 "AU Renewal Application" to the RSC. To amend the permit on the RSO-3, submit page 1 with "Amendment" marked, page 5 with signature, and other pages containing modifications. If the amendment is for possession quantity only, a memo indicating the desired change may be submitted.

## **6. INDIVIDUAL RESPONSIBILITY**

### **a) All Users**

Each individual at VHS, regardless of category or authorization, who has contact with radioactive materials or other radiation sources is responsible for the following:

- i. Be familiar with the VHS Radiation Safety Manual.
- ii. They shall keep their radiation exposure and that of those working under their supervision ALARA, specifically below the maximum permissible doses listed in 12VAC5-481 and Section 10 of this manual. Concentrations of radioactive materials in laboratory air shall be maintained below the levels specified in 12VAC5-481-670.
- iii. Wear prescribed radiation dosimeters in radiation areas. Personnel who work only with alpha or beta emitters with a maximum energy of less than 200 keV will not be issued dosimetry.
- iv. According to their approved permit, conduct precautionary personnel surveys at frequent intervals with a suitable survey instrument and maintain the required records.
- v. Limit the use of radionuclides to individuals working under their direct supervision and to the location specified in their permit.
- vi. Keep current working records of the receipt and disposal of radionuclides in their possession (e.g., research, waste disposal, transfer, storage, records, etc.). The Radiation Safety Office reserves the right to audit these records anytime.
- vii. Transfer radioactive materials per this manual and all applicable regulations.
- viii. Assure that smoking, eating, drinking, and applying cosmetics are prohibited in areas where unsealed radioactive materials are present.

### **b) Authorized Users**

In addition to the items listed above, Authorized Users are further responsible for:

- i. Adequate planning. Before an experiment, the User should determine the types and amounts of radiation or radioactive material required. This will generally dictate the level of protection needed. Procedures must be well outlined. In most cases, before the procedure is performed with radioactive materials, it should be rehearsed to preclude accidents or unexpected circumstances.
- ii. Be readily available when radionuclides in their permit are being used.
- iii. Instructing Qualified and Restricted Users to use safe techniques and apply approved radiation safety practices.
- iv. Furnishing the Radiation Safety Officer with information concerning individuals and activities in their areas, particularly additions to or deletions from their personnel rosters.
- v. Contacting the RSO whenever changes in operational procedures may lead to potential personnel exposure.
- vi. Complying with the regulations governing the use of radioactive materials established by the Nuclear Regulatory Commission, Commonwealth of Virginia, and the VHS Radiation Safety Committee for:

- Following the correct procedure for procurement of radioactive materials by purchase or transfer.
- Posting indicators of radiation areas and areas where radioactive materials are used or stored.
- Accounting for the disposition of radioactive materials in their possession. Inventories of nuclides must be completed and received by the RSO every six months.
- Assuring that all radioactive waste materials are consigned to the Radiation Safety Office for disposal.
- Reporting any incident or unusual occurrence related to the radioactive material or radiation-producing equipment in their possession.
- Informing the Radiation Safety Committee before any minors (persons under 18) engaging in radiation and radioactivity activities.
- Informing the Radiation Safety Officer before any declared pregnant woman who may be occupationally exposed to ionizing radiation.

## **7. RADIATION PROTECTION PROCEDURES**

This section aims to provide a safe working environment for laboratory personnel, ensure public safety, and avoid contamination of equipment and facilities.

### **a) Authorized User**

- i. Discuss the work to be done and the necessary safety precautions with employees.
- ii. Outline the procedure for each job in writing (the amount of detail should be commensurate with the potential hazards).
- iii. Stock the laboratory with plastic or rubber gloves, lab coats, warning tags, labels, wipes, appropriate survey/counting instruments, forms for necessary records, plastic bags and tape for waste disposal, absorbent paper, etc. Proper tools and supplies greatly enhance the use of good procedures.
- iv. Make arrangements with the Radiation Safety Office for radioactive waste disposal.
- v. Have available and appropriate use of remote handling devices, automatic pipettes or dispensers, tongs, etc., to manipulate and transfer radioactive preparations.

### **b) Rules and Procedures for Laboratory Personnel**

Only individuals authorized by the Radiation Safety Committee may handle radioactive material in designated areas according to their approved permit. Radiation Safety Office staff may use accepted health physics practices and procedures to handle radioactive materials.

### **c) General Rules and Procedures**

The following rules and procedures apply to all uses of radioactive material:

- i. When working with radioactive materials, wear a lab coat or other protective clothing. Remove and secure the lab coat within the lab BEFORE LEAVING.
- ii. Wear non-powdered disposable gloves when handling radioactive material. *Change gloves frequently to prevent the spread of contamination.*
- iii. Remove gloves from the work area. Do not touch faucets, light switches, computer keyboards, telephones, doorknobs, or other common-use items with contaminated or potentially contaminated gloves.
- iv. Monitor hands, feet, and clothing in a low background area after procedures or before leaving the lab.
- v. Do not eat, drink, smoke, or apply cosmetics in areas where radioactive material is used or stored.
- vi. Use mechanical pipetting devices.

### **d) Contamination Control**

- i. Designate an area in the lab to conduct work with radionuclides. Place plastic-backed absorbent material on the work area and radiation tape on the boundary of the absorbent material. Monitor the work area and dispose of contaminated materials.
- ii. Mark equipment and lab ware used for work with radioactivity with radiation tape to indicate it may contain contamination.

- iii. Designate a sink for cleaning contaminated glassware. Notify Radiation Safety so a tag can be placed on the sink trap to alert Maintenance to the need for monitoring and protective procedures before and during repair work.
- iv. Place radioactive material labels on storage areas such as refrigerators, freezers, and other such areas. Ensure that containers containing radioactive material are clearly marked with radiation labels that identify the radionuclide, quantity, and date.
- v. Perform surveys per the requirements of their approved protocols and the procedures in the "Surveys" section.

**e) Personnel Monitoring and Area Monitoring**

- i. If you are issued a radiation monitoring device(s), wear it in radioactive materials storage or use areas. If you lose the dosimeter, immediately notify the Radiation Safety Office.
- ii. Do not handle dosimetry (personnel or area) with potentially contaminated gloves.

**f) Use of Protective Equipment**

- i. When using unsealed beta-emitting radionuclides with energies greater than 250 keV, place an acrylic or equivalent shield between the user and the source. The shield should be at least ¼ inches thick. Additional shielding may also be necessary behind the source to prevent exposure to coworkers on the other side of the bench.
- ii. Use protective eyewear when pipetting liquids containing radioactivity.
- iii. Respirators used for protection from airborne radioactivity must be approved in advance by Environmental Health & Safety in consultation with the RSO.

**g) Special Procedures**

- i. Iodination
  - Oxidative iodination (such as the iodine monochloride, lactoperoxidase, and chloramine-T processes) risks releasing radioactive iodine gas into the atmosphere. To protect personnel and the environment, oxidative iodinations must be performed according to the following procedures, in addition to the General Procedures listed above.
  - The iodination and all steps involving the potential release of radioactive iodine gas must be performed in an operating radiochemical fume hood with a volume flow rate of at least 15,000 liters per minute (430 CFM) and a face velocity of at least 40 meters per minute (130 FPM). Filters to trap the radioactive iodine gas shall be employed. The fume hood must not be shut off for at least 24 hours after the last iodination.

**Iodination**

- All iodinations will be performed in the EH&S fume hood.
- Contact EH&S at least 21 days in advance to schedule the activity.
- EH&S will perform a baseline thyroid assay of the User and monitor for contamination during the procedure.
- A follow-up thyroid assay will be performed 24-96 hours after the iodination and again 14-16 days later.

- Authorized Users and other radiation workers will cooperate with Radiation Safety staff to perform breathing zone and environmental air sampling as necessary by the RSO.
- Radiation workers involved in the iodination and preliminary purification steps will have thyroid counts performed before, 24-96 hours after, and 14-16 days after each iodination procedure or every two weeks during repeated iodinations.
- The pH of liquid radioactive wastes from iodination procedures must be alkynized to reduce the off-gassing of radioactive iodine.

ii. Recommendations for the Use of Tritium-Labeled Sodium Borohydride

Sodium borohydride (NaBH<sub>4</sub>), labeled with tritium, is a valuable reagent for reducing certain organic compounds and labeling them with tritium. It is very hygroscopic and readily hydrolyzes (even with humidity) to release tritium gas. However, it is unstable in any solution containing hydrogen ions, although its useful life in solution can be extended by alkalizing it.

**Increase pH of Iodination Waste**

- Addition of a base
- Raise to pH 9 or above
- Reduces gas release by driving the reaction to the left:  

$$4\text{I}^- + \text{O}_2 + 4\text{H}^+ \leftarrow 2\text{I}_2(\text{gas}) + 2\text{H}_2\text{O}$$

iii. Tritium-Labeled Sodium Borohydride Procedure

Use the following procedure when using tritiated NaBH<sub>4</sub>:

- All work with the crystalline stock material or solutions must be performed in a functional fume hood. This includes initial unpacking, as all vials of stock material contain high concentrations of radioactive gas, and weighing out the stock. When hood operations are impossible, such as during centrifugation or shaking operations, containers must be tightly covered with caps or two layers of paraffin film.
- Monitor all areas where NaBH<sub>4</sub> (<sup>3</sup>H) has been used to remove contaminants by performing wipe tests and counting the particles in a liquid scintillation counter.
- **Do Not** mouth pipette radioactive solutions.
- In all radioactive operations, wear disposable waterproof gloves, cover work areas with plastic-backed absorbent material, *and change gloves frequently*.
- All liquid waste should be acidified, stored in a hood for at least 24 hours, and boiled if possible. The acidification will degrade the BH<sub>4</sub> ions, and the boiling will remove any dissolved tritium gas. Bubbling a gas such as nitrogen through the solution is equivalent to boiling. Collect aqueous waste, assay it for radioactivity, and prepare an RSO-10, "Request for Radioactive Waste Collection."
- Check frequently to ensure adequate hood operation.
- Bioassays are required when using more than 100 mCi per week.
- NaBH<sub>4</sub> (<sup>3</sup>H) should be stored in a desiccator and opened only in a hood.
- If the reagent is always kept dry, it will degrade more slowly. Using a "dry bag" (such as glove bags purged with nitrogen) will increase the useful life of stock material and release less gas.

## **8. RADIATION MONITORING AND CONTROL**

### **a) Surveys**

Radiological surveys of areas where radioactive materials are used, stored, or released are essential to a radiation safety program. Records of surveys are required by law and will be examined in each Authorized User's work area during regulatory inspections, external audits, and inspections by Environmental Health & Safety. Records must be signed and dated. Survey records are the property of the licensee, not the User.

A complete survey may include monitoring for fixed and removable contamination, exposure rate measurements, and hazard evaluations.

- i. Fixed contamination is radioactive material that has bound to or leached into a surface and is not readily removable. It is detected with a survey instrument that can detect the type and quantity of radioactive material present. With the exception of tritium, most common biomedical radioactive tracers can be detected with a thin-window Geiger-Mueller survey instrument.
- ii. Removable contamination is a greater potential hazard because it may be unknowingly transferred from one place to another. Wipe tests are used to obtain samples from surfaces potentially contaminated with radioactive material. A wipe, either a small filter paper or a cotton swab moistened with a solvent (water or isopropyl alcohol), is wiped over the surface. The wipe is then prepared for counting in either a liquid scintillation or gamma counter.
- iii. Exposure rate or dose rate measurements must be made and recorded in areas with potential for exposure to external sources. This excludes low-energy beta emitters, such as  $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{33}\text{P}$ ,  $^{35}\text{S}$ , and  $^{45}\text{Ca}$ , but includes  $^{32}\text{P}$  and gamma-emitting sources. G-M detectors may be used for exposure rate measurements if calibrated to the energy in question. Ion chamber instruments are best for measuring exposure rate, although they are usually less sensitive than G-M detectors. Ion chambers are also more accurate and can be made relatively energy independent. A thin crystal sodium iodide detector is most appropriate for  $^{125}\text{I}$  surveys.
- iv. The RSO will periodically evaluate hazards, but all radiation workers must be alert for radiological and other hazards in the laboratory.
- v. Document surveys by making a diagram of the lab area and indicating all fixtures, such as fume hoods, sinks, workbenches, and freezers. Label areas with numbers and record counts at these numbers each time a survey is made. Sign and date the survey.

Other kinds of surveys include air and water sampling as deemed necessary by the RSO and monitoring incoming and outgoing shipping containers. The RSO will survey each Restricted Area at least quarterly and conduct other surveys as needed.

### **b) Periodic Survey Frequency**

To determine the frequency for your lab, identify the radionuclide from the Group table below, then identify the amount of activity handled at one time from the Survey Frequency category table. Users handling  $^{32}\text{P}$  and gamma-emitting radionuclides must perform an instrument survey of their work area and themselves.

**Radionuclide Groups** (only representative radionuclides are listed that correspond to those likely to be used in this license. Other radionuclides in each group are the same as those listed in VAREG-EPI-720G, Appendix R.)

Group 1	<sup>226</sup> Ra
Group 2	<sup>22</sup> Na, <sup>36</sup> Cl, <sup>45</sup> Ca, <sup>60</sup> Co, <sup>90</sup> Sr, <sup>125</sup> I, <sup>126</sup> I, <sup>131</sup> I, <sup>133</sup> I, <sup>137</sup> Cs
Group 3	<sup>14</sup> C, <sup>18</sup> F, <sup>32</sup> P, <sup>33</sup> P, <sup>35</sup> S, <sup>51</sup> Cr, <sup>57</sup> Co, <sup>63</sup> Ni
Group 4	<sup>3</sup> H, <sup>129</sup> I

**Survey Frequency Category**

Group	Low	Medium	High
1	<10 µCi	10 µCi to 1 mCi	>1 mCi
2	<1 mCi	1 mCi to 100 mCi	>100 mCi
3	<100 mCi	100 mCi to 10 Ci	>10 Ci
4	<10 Ci	10 Ci to 1000 Ci	>1000 Ci

**Survey Frequency** is based on group and category:

- **Low**-frequency surveys are conducted not less than once a month
- **Medium**-frequency surveys are conducted not less than once per week
- **High**-frequency surveys are conducted not less than once per normal working day.

**c) Exemption from Survey**

If the following criteria are met and written approval by the Radiation Safety Officer is granted, periodic surveys performed by the Authorized User will not be required until radioactive materials are brought into the laboratory:

- i. The Authorized User has not received any Level 2 (written reprimand) Corrective Action Notices within the previous six months.
- ii. The last quarterly contamination survey by Environmental Health & Safety indicated no removable contamination was present.
- iii. No radioactive material has been present or brought into the laboratory since the last quarterly contamination survey performed by Environmental Health & Safety – this includes:
  - Radioactive materials
  - Radioactive samples
  - Radioactive wastes

To help ensure the effectiveness of the radiation safety program, the following laboratories cannot be exempted from the periodic survey requirements:

- i. Laboratories that have liquid scintillation or gamma counters.
- ii. Core laboratories or laboratories are used as core labs with space or equipment for radioactive materials.

To take advantage of the survey exemption, the Authorized User must:

- i. Submit a written request for periodic contamination survey exemption to Environmental Health & Safety. The request must include:
  - Authorized User's name
  - Location – building and room number
- ii. Continue performing periodic contamination surveys until written approval of the exemption is received from the RSO.
- iii. The Authorized User must complete monthly documentation that no radioactive materials have been brought into or used in the laboratory under exemption using the RSO-5, "Periodic Contamination Survey Exemption" form. This documentation shall be included in the contamination surveys in the Authorized User's radiation safety manual.
- iv. Submit a written notice to Environmental Health & Safety when radioactive materials use will resume in the laboratory under the exemption. This must be received before radioactive materials may be ordered or brought into the laboratory. The notice must include:
  - Authorized User's name
  - Location – building and room number
  - When and what radioactive materials will be received

**d) Removable Surface Contamination Action Levels**

- i. For removable surface contamination, an action level falling outside of the acceptable contamination range will require decontamination to be performed and completed. After decontamination, a survey is required to document its effectiveness.
- ii. To find the background value using a handheld detector, turn on the detector in the area and wait a few minutes while looking at the detector window. The meter usually is in counts per minute (CPM). To convert CPM to DPM:

$$\text{DPM} = \text{CPM}/\text{efficiency of the instrument}$$

Areas such as fume hoods, glove boxes, and other containment facilities are exempted from these action levels. Contamination detected in unrestricted areas shall be immediately decontaminated to background levels. *If it is not possible to achieve background level,* removable contamination may not exceed the 2,000 DPM/100 cm<sup>2</sup> above background.

If the spread of radioactive contamination is suspected, all work in the area shall be halted immediately. The RSO should be contacted as soon as possible. See Appendix A, Emergency Procedures.

- i. Fixed contamination in excess of these action levels requires action to reduce potential personnel exposure. These actions may include marking and placing shielding over the area or physically removing the contamination via a destructive process.

e) **Exposure Rate Limits**

Exposure rates must be controlled within the action levels below. In Restricted Areas, the exposure rate may exceed the action level for a short duration if steps are taken to control the total dose equivalent within the limits in Section 12. Barring the above exceptions, action must be taken to reduce the exposure rates as far *as reasonably achievable* below these levels.

Area	Action Levels	
Restricted	5 mrem/hour	100 mrem/40 hour
Unrestricted	2 mrem/hour	100 mrem/year

f) **Survey Instruments**

The Radiation Safety Committee requires Authorized Users to have immediate access to suitable survey instruments such as G-M detectors. Such instruments will be maintained and calibrated as described in Section 9 of this manual.

## **9. INSTRUMENT CALIBRATION**

### **a) General**

Radiation detection instruments require at least annual calibration. The Radiation Safety Office will maintain records of instrument calibration.

### **b) Calibration**

i. Calibration of survey meters shall be performed with radioactive sources such that the:

- Sources are approximate point sources.
- Source activities are traceable within 5% accuracy to the National Institute of Standards and Technology (NIST) calibrations.
- Calibration frequency is at least annually.
- Readings should be taken at two points on each scale (approximately  $\frac{1}{3}$  and  $\frac{2}{3}$  of full scale, respectively.)
- The instrument reads within  $\pm 20\%$  of the actual value. Read the appropriate section of the instrument manual to determine how to make necessary adjustments to bring the instrument into calibration.

#### **Calibration Expenses**

- EH&S will calibrate instruments within the limits of their capability.
- If an instrument needs to be calibrated or repaired by a third party, the user is responsible for all costs.

ii. Sources of  $^{137}\text{Cs}$  or  $^{60}\text{Co}$  are appropriate for the calibration performance. The instrument must be calibrated at lower energies if its response is *energy-dependent* and it is to be used to *measure*  $^{125}\text{I}$ ,  $^{133}\text{Xe}$ , or  $^{99}\text{Tc-m}$ . This calibration may be done either:

- With calibrated standards of radionuclides at or near the desired energies or
- As a *relative intercomparison* with an *energy-independent* instrument and uncalibrated radionuclides.

### **c) Pulser Calibration**

This is a calibration method for counts per minute (CPM) survey instruments used for detecting and measuring contamination levels:

- Introduce pulses into the circuit at the connection to the radiation detector. The pulses should be similar to those produced by actual ionizing events.
- Adjust the instrument to  $\pm 20\%$  when measured at two points on each instrument scale (approximately  $\frac{1}{3}$  and  $\frac{2}{3}$  of full scale recommended). This will set the linearity on all ranges.
- After linearity is set, reattach the detector and use calibrated beta sources of various beta energies to determine the instrument's efficiency for each desired energy. Use long half-life beta sources as appropriate.
- If desired, a plot of beta energy (maximum) versus instrument response (efficiency) can be made.
- Beta sources that produce 2,000 to 5,000 CPM are sufficient; the Pulser will be used to check the low and high ranges.

**d) Reference Check Source**

A reference check source of a long half-life, e.g.,  $^{137}\text{Cs}$ , shall also be read at the time of the above calibration. The reading shall be taken with the detector placed in close proximity (contact) to the check source. A reading of this reference check source should be taken:

- i. Before each use
- ii. After each maintenance and/or battery change
- iii. At least quarterly

The instrument should be operationally checked and recalibrated as necessary if any reading is not within  $\pm 20\%$  of the reference check source reading.

## **10. RADIATION DOSE LIMITS**

### **a) General**

The use of radioactive material and radiation-producing machines may result in employee exposure. Procedural and administrative protection practices are developed to minimize radiation dose to employees and members of the general public in unrestricted areas. Applying these dose limits will ensure that individuals do not exceed acceptable risk levels from exposure. In all cases, the objective is to keep radiation dose ALARA.

### **b) Adults**

Radiation dose shall be controlled so the limits listed below are not exceeded, except for planned special exposures. Although a planned special exposure is unlikely to be permitted, the conditions 12VAC5-481-690 must be met if one is deemed necessary.

Area Measured	Limit per year (rem)
Total effective dose equivalent or,	5
Sum of deep dose equivalent and the committed dose equivalent to any individual organ or tissue	50
Eye	15
Shallow dose equivalent to skin or extremity	50

### **c) Minors**

The annual occupational dose limits for minors are 10 percent of the dose limits for adults. A minor is defined as an individual less than 18 years of age.

### **d) Dose to Embryo/Fetus**

The limit is 500 mrem Total Effective Dose for the declared gestational period. This reduction is due to the increased sensitivity of rapidly developing cells. Efforts to maintain exposure less than 0.05 rems per month will ensure the total dose remains within the limit.

The pregnant worker must notify the Radiation Safety Officer in writing to declare a pregnancy. Counseling by the Radiation Safety Officer will be offered and includes topics regarding dose limits for the term of pregnancy and risk factors from NRC Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure." The RSO will also assess her potential external and internal dose based on the type and quantities of radionuclides used in her work. The declared pregnant worker will be automatically assigned a secondary abdomen dosimeter. The results of her monitoring will be reported monthly throughout the remainder of the gestation period.

e) **Individual Members of the Public**

Dose to members of the public, such as visitors, shall be kept ALARA but not to exceed 0.1 rem per year, exclusive of dose contribution from sewer disposal of radioactive materials. Additionally, the dose in unrestricted areas from external sources shall not exceed 0.002 rems in one hour.

f) **Internal Dose**

Most radionuclide manipulations at VHS present minimal likelihood for inhalation or ingestion of radionuclides; therefore, internal occupational doses are not anticipated. If a protocol or procedure contains a potential for an occupational intake, the Authorized User will initiate actions to ensure the intake doesn't exceed two percent of the Allowable Limit on Intake (ALI). *Respiratory protection factors shall not be used to determine compliance with this limit.*

g) **As Low as Reasonably Achievable Guidelines**

Radiation dose limits are established to ensure occupational workers, and the general public receive minimal radiation exposure. Most operations at VHS are readily accomplished within these limits; however, administrative dose guidelines are established to further reduce exposure and to alert the individual and EH&S to potential situations where unnecessary dose may be received. Radiation exposure is minimized through proper planning, use of containment and shielding, and application of good radiation protection practices. It is further minimized when radioactive material and radiation producing machines are used by faculty and staff with training and experience in its use and frequent consultation between users and EH&S personnel.

<b>VHS Clinical ALARA Warning Levels (mrem/year)</b>					
	<i>Level 1</i>		<i>Level 2</i>		<b>Annual Limit</b>
	Monthly	Quarterly	Monthly	Quarterly	
Whole Body	250	625	375	1,000	5,000
Any Organ	2,500	6,250	3,750	10,000	50,000
Skin	2,500	6,250	3,750	10,000	50,000
Extremity	2,500	6,250	3,750	10,000	50,000
Lens of Eye	750	1,875	1,125	3,000	15,000
<b>VHS Non-Clinical ALARA Warning Levels (mrem/year)</b>					
	<i>Level 1</i>		<i>Level 2</i>		<b>Annual Limit</b>
	Monthly	Quarterly	Monthly	Quarterly	
Whole Body	42	125	125	375	5,000
Any Organ	417	1,250	1,250	3,750	50,000
Skin	417	1,250	1,250	3,750	50,000
Extremity	417	1,250	1,250	3,750	50,000
Lens of Eye	125	375	375	1,125	15,000

*All units are in mrem.*

- i. External Exposure. Two Investigational Levels are set to alert EH&S and the individual of their dose received during the dosimeter-wearing period:
- Level 1, the RSO will send a memo to the individual, advising them of their dose.
  - Level 2, the RSO will send a memo to the individual, advising them of their dose, and they are required to respond to a questionnaire regarding the work practices that led to the accumulation of the dose.
- ii. Internal Exposure. Prudent use of in vivo and in vitro bioassays ensures that work practices minimize the intake of radionuclides. In the event bioassays reveal an intake, the magnitude of the intake will dictate further evaluation or investigation. For intakes that are 0.02 times ALI, further evaluation is conducted, including at least two additional bioassay measurements and a review of procedures that may have resulted in the intake.

Example:  $^{125}\text{I}$

- $40 \mu\text{Ci} \times 0.02 = 0.8 \mu\text{Ci}$  or 800 nCi)
- $40 \mu\text{Ci} \times 0.1 = 4 \mu\text{Ci}$

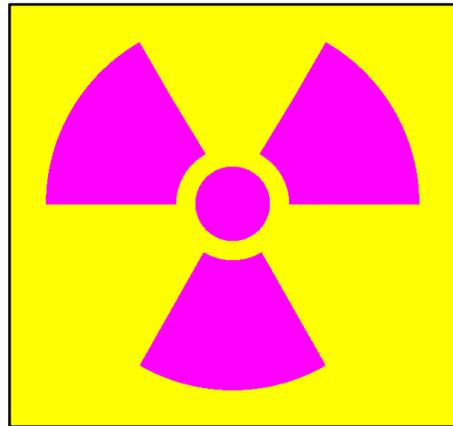
If the intake is greater than 0.1 times ALI, a thorough investigation, including additional bioassay measurements, will be performed to obtain sufficient data to determine excretion and retention functions and quantify the initial intake. These measurements and results will be retained permanently as part of the individual's dosimetry record.

## **11. POSTING AND LABELING**

Radioactivity or radiation fields are identified by the standard radiation symbol, a magenta three-bladed (trefoil) design on a yellow background. Rooms, areas, or equipment where radioactive materials are used or stored shall be clearly marked with radiation signs and labels to alert individuals to their presence.

### **a) Posting Signs**

- i. Very High Radiation. An area where an individual could receive an absorbed dose in excess of 500 rad in 1 hour. This area shall be posted with a radiation sign containing "GRAVE DANGER, VERY HIGH RADIATION AREA."
- ii. High Radiation Area. An area where an individual could receive a dose equivalent to more than 100 mrem in 1 hour at 30 centimeters (12 inches) from the source. This area shall be posted with a radiation sign containing the "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA."
- iii. Radiation Area. An area where an individual could receive a dose equivalent to more than 5 mrem in 1 hour at 30 centimeters (12 inches) from the source. This area shall be posted with a radiation sign containing "RADIATION AREA."
- iv. Radioactive Materials. Rooms or areas where radioactive material is used or stored in quantities exceeding 10 times the amounts listed in 12VAC5-481-3700 shall be posted with a radiation sign containing the words "CAUTION RADIOACTIVE MATERIAL," or "DANGER, RADIOACTIVE MATERIAL." Examples are rooms containing activity greater than 10 mCi of  $^3\text{H}$ , 1 mCi of  $^{35}\text{S}$ , 0.1 mCi of  $^{32}\text{P}$ , or 0.001 mCi of  $^{125}\text{I}$ .



### **b) Exceptions to Posting Signs**

- i. Caution signs are not required if rooms or areas contain:
  - Radioactive material is used for less than eight hours per day, and the room is constantly attended to by an individual trained in radiation protection practices.
  - Sealed sources where the radiation level at 30 centimeters from the surface of the container is 5 mrem per hour or less.

#### Posting Summary

- Very High Rad Area = >500 rad/1 hour
- High Rad Area = >100 mrem/1 hour @ 30 cm
- Rad Area = >5 mrem/1 hour @ 30 cm
- RadMat = >10x listed quantities

**c) Labeling Containers**

Each container of radioactive material or piece of laboratory equipment used to handle radioactive material must have a label with the radiation symbol and the words "CAUTION RADIOACTIVE MATERIAL" or "DANGER RADIOACTIVE MATERIAL." The label must also identify the radionuclide, activity, date of activity determination, exposure rate, if applicable, and the name of the Authorized User. When the containers and equipment are free of radioactive contamination (as determined by survey), the labels shall be removed or obliterated to indicate that the material is no longer radioactive.

Labels are not required for:

- i. Containers with quantities less than that listed in Appendix C. Examples are containers with less than 1.0 mCi of  $^3\text{H}$ , 10  $\mu\text{Ci}$  of  $^{32}\text{P}$ , 100  $\mu\text{Ci}$  of  $^{35}\text{S}$ , and 1  $\mu\text{Ci}$  of  $^{125}\text{I}$ .
- ii. Containers attended by an individual trained in radiation protection practices.

**d) Restricted Area**

Access is controlled in a restricted area to protect individuals against risks posed by radiation and/or radioactive material. Restricted areas include laboratories where radioactive material is used or stored and other rooms or areas that contain radiation-producing machines or radioactive materials.

## **12. PERSONNEL MONITORING AND BIOASSAY PROCEDURES**

### **a) General**

Personnel monitoring is used to demonstrate employee exposures comply with occupational dose limits. Monitoring may consist of dosimeters to measure external dose or bioassays to determine the dose due to intake of a radionuclide. The necessity to monitor an individual is determined during the review of the proposed use of radioactive material or radiation-producing machines. A wide variety of materials and technologies can be used for personnel dosimetry. Bioassays may be performed by assaying biological samples such as mucus and urine or determining radioactivity in an organ such as the thyroid.

### **b) External Monitoring**

Individual radiation dosimeters are issued to adults likely to exceed 10 percent of the annual occupational dose limit. Minors and declared pregnant women are issued radiation dosimeters when they are likely to exceed 0.050 rems in a year from external sources.

#### **i. Exchange Frequency**

Most workers exchange their radiation dosimeters (whole body, wrist, or finger) every three months. Clinical workers, including medical residents, exchange their dosimeters monthly. Replacement dosimeters are issued to work centers during the first week of each issue period to be exchanged with dosimeters from the previous issue period.

#### **ii. Lost or Damaged Dosimeter**

VHS EH&S is authorized to recover lost and late fees incurred by departments that do not return dosimetry on time or return it damaged. The fee schedule is communicated to departments annually and may change based on market conditions.

When a dosimeter is lost or damaged so that it can't be evaluated, a dose estimate must be made for the dosimeter issue period. A dosimeter not returned after exchange may also require a dose estimate, particularly if it's over several months since the issue period. To obtain information for a dose estimate, the Radiation Safety Office communicates with the individual, advising them of the loss/damage and requesting that information be provided about their exposure to ionizing radiation during the period, as well as to identify coworkers receiving similar exposure. This information and previous exposure history are used to estimate the individual's dose for the period in question. The dose estimate is then recorded in the individual's permanent exposure record.

#### **2025 Late & Lost Dosimeter Fees**

- Up to 30 days late: \$10
- Up to 60 days late: \$20
- Up to 90 days late/lost: \$30

Changes based on market conditions may occur and will be communicated to departments annually.

c) **Bioassays**

Bioassays are performed where it is likely that an individual could, in one year, receive an intake of a radionuclide over 10 percent of the ALIs in Table 1, columns 1 and 2 of 12VAC5-481-3690. Additionally, where minors and declared pregnant women could receive a committed effective dose equivalent of 0.05 rem in one year, the intake shall be assessed by monitoring airborne contaminants and/or bioassay.

i. Radioiodine

Bioassays will be performed on individuals using radioiodine using the methods and quantities described in NRC Regulatory Guide 8.20, "Applications of Bioassay for Radioiodine." Before the work, individuals performing iodinations will have a baseline thyroid count. A follow-up thyroid assay will be performed 24-96 hours after the iodination and again 14-16 days later. Breathing zone air sampling may also be conducted during the iodination procedure.

ii. Tritium

Bioassays will be performed by urinalysis for individuals using tritium ( $^3\text{H}$ ) in procedures and quantities described in NRC Regulatory Guide 8.32 "Criteria for Establishing a Tritium Bioassay Program."

If a bioassay measurement indicates internally deposited radioactive material, additional measurements will be obtained. If initial bioassay measurements indicate an intake greater than 0.02 ALI, at least two additional measurements will be obtained to evaluate the intake. If the intake is estimated to be greater than 0.1 ALI, a complete investigation should include additional bioassay measurements to establish retention and excretion functions and evaluate work practices during the iodination procedure.

## **13. RADIOACTIVE WASTE DISPOSAL PROCEDURES**

### **a) General**

Research with radioactive material generates waste in solids, liquids, liquid scintillation vials, and animal carcasses. Investigators using radioactive material are responsible for minimizing the volume of waste generated and consider the use of alternate short half-life (<120 days) radionuclides when possible. Radioactive material combined with EPA Hazardous Waste constitutes a mixed waste for which there is expensive and limited national capacity for waste disposal. Steps should be taken to avoid generating mixed waste. The RSO must be notified in advance if it is to be generated. All chemical constituents must be listed on waste disposal forms.

The Radiation Safety Office provides waste disposal services, including bulk containers, polyethylene bags, forms, and consultation on unique wastes. The Authorized User is responsible for segregating waste by physical form (i.e., solid, liquid, animal carcasses, and liquid scintillation vials), radionuclide, and half-life. Once segregated and appropriately packaged, a request form RSO-10, "Request for Radioactive Waste Collection," is sent to Radiation Safety to collect and dispose of the waste. Documentation of radioactive waste disposal must be maintained to comply with the provisions of the VHS license.

### **b) Preparing Radioactive Waste for Disposal**

Waste must be segregated by physical form, radionuclide, and half-life. Fire hazards from flammable liquid scintillation cocktails must also be considered. The waste storage area is a "Restricted Area, " meaning it MUST ALWAYS BE KEPT SECURE.

#### **i. Solid Waste**

Place solid waste (bench paper, absorbents, gloves, pipette tips, contaminated articles, etc.) in the waste container provided by the Radiation Safety Office. The containers are 20 or 30-gallon waste cans with a poly liner. When waste is put in the container, make an entry on the attached form RSO-10a "Radioactive Waste Drum Contents" with the date and activity in units of  $\mu\text{Ci}$  or  $\text{mCi}$ .

#### **DO NOT MIX RADIONUCLIDES IN ONE WASTE CONTAINER**

#### **ii. Liquid Waste**

Collect liquid waste in plastic containers (1 liter or smaller). Acidic or basic waste must be neutralized to pH 6-8.

#### **DO NOT MIX HAZARDOUS CHEMICAL WASTE WITH RADIOACTIVE WASTE**

Place radiation warning tape on the side of the bottle to identify it as containing radioactive material. When the container is nearly full, prepare an RSO-10 indicating the radionuclide, activity (total  $\mu\text{Ci}$  in the container), and liquid volume.

To determine the total activity in the liquid waste, take a 1 ml aliquot, place it in a liquid scintillation vial with a cocktail for beta counting or an empty vial for gamma counting, and count the sample. Using the efficiency determined for the counter, convert the output in counts per minute (CPM) to disintegrations per minute (DPM) and then to units of  $\mu\text{Ci}$  or  $\text{mCi}$ .

Convert CPM to units of activity, record the activity on the RSO-10, and submit it to the Radiation Safety Office:

$$\text{Total } \mu\text{Ci} = (\text{CPM} / \text{Efficiency}) \times (4.5 \text{ E-}7 \text{ } \mu\text{Ci/DPM}) \times (\text{volume in ml})$$

4.5E-7 is the reciprocal of the conversion factor 2.2E6 DPM/ $\mu$ Ci

iii. Liquid Scintillation Vials

Place liquid scintillation vials containing cocktails in their shipping flat. When the flats are ready for disposal, estimate the total activity ( $\mu$ Ci) and mark it on the side of the flat. Activity is estimated by counting 5 to 10 vials and calculating the average activity per vial. The product of activity per vial times the number of vials is the total activity in the flat.

**NOTE:** Vials containing less than 0.05  $\mu$ Ci/g of  $^3\text{H}$  and  $^{14}\text{C}$  in the medium used for liquid scintillation counting may be disposed of as if they were not radioactive. Complete an RSO-10 and submit it to the Radiation Safety Office for collection.

iv. Animal Carcasses

Animal carcasses containing radioactivity must be double bagged (poly), labeled with the radionuclide and activity ( $\mu$ Ci or mCi), and frozen, awaiting pick-up by Radiation Safety. Activity is determined by using the activity injected into the animal to determine if there is negligible loss through excreta or the difference between activity injected and activity excreted (solid or liquid waste). For carcasses containing  $^3\text{H}$  or  $^{14}\text{C}$ , the animal's weight must also be included. Animal tissue containing less than 0.05  $\mu$ Ci/g of  $^3\text{H}$  and  $^{14}\text{C}$ , when averaged over the weight of the whole animal, may be disposed of as if it were not radioactive.

Example:

- A 250-gram carcass containing 12.5  $\mu$ Ci of  $^{14}\text{C}$  would have an average concentration of 0.05  $\mu$ Ci/g.
- Complete an RSO-10 and submit it to the Radiation Safety Office for collection.

v. Sanitary Sewer Disposal

**No radioactive waste may be disposed of in the sanitary sewer by Authorized, Qualified, or Restricted Users.**

c) **Records**

The Authorized User is responsible for keeping records of waste disposal by radionuclide activity, form, and date disposed of. This information is necessary to complete the semi-annual inventory of radionuclides.

## **14. ANIMAL USE PROCEDURES**

### **a) Animals and Radioactive Materials: Rules and Procedures for Authorized Users**

Posting and Labeling. The Authorized User is responsible for ensuring that cages are correctly marked and labeled, and rooms are appropriately posted.

- i. Cage cards must be marked with the radiation trefoil symbol if they contain animals with more than ten percent of the limits in 12VAC5-481-3700. The radionuclide, date, activity (in mCi), and name and phone number of the Authorized User (or Qualified User) must be marked on the cage card. When it is not possible to label cages, i.e., non-human primates, the room sheet on the entry door will contain a radiation trefoil symbol over the cage locations that contain animals with radioactivity, the name of the radionuclide, activity, and name of the investigator.
- ii. Rooms with a nuclide value more than ten times the value listed in 12VAC5-481-3700 must have a radioactive material sign on the door.

### **b) Containment**

Authorized Users must use under pads and other appropriate methods to collect excreta and contain radioactive waste. They are also responsible for ensuring that radioactive waste is disposed of properly and recorded. For assistance on carcass disposal, contact the Radiation Safety Office.

### **c) Waste Disposal**

- i. Litter, bedding, under pads, and carcasses containing radioactivity must be disposed of as radioactive waste unless otherwise specified by regulation. Radiation Safety will provide a container with a radiation marking for solid waste. Waste should be placed in the container, and the RSO-10a, "Radioactive Waste Drum Contents," should be completed, indicating the date, radionuclide, and activity disposed of.
- ii. Liquid waste should be collected in poly bottles. Label the bottles with radiation tape and identify the radionuclide and activity.
- iii. Carcasses must be placed in double poly bags, each sealed separately. They must then be labeled with radiation tape or a tag identifying the radionuclide, activity, and investigator. The carcasses must be placed in a freezer and awaiting disposal by Radiation Safety.
- iv. Complete an RSO-10 "Request for Radioactive Waste Collection" and send it to Radiation Safety. You will be contacted to schedule the waste collection.
- v. Cages are considered contaminated until surveyed and decontaminated. The Authorized User will ensure that cages are surveyed and decontaminated and maintain records of the survey and resurvey(s). Likewise, after cleaning cages, the Authorized User will survey the room to assess potential contamination. The room will not be released for general use until Radiation Safety has reviewed and approved the survey data.
- vi. Special instructions for caretakers must be written and posted on or near the animal cages. Investigators should also provide special instructions in case of animal death or illness.

- vii. In cases where the cages or a room must be specially cleaned or decontaminated, the Authorized User is responsible for cleaning or supervising the cleaning.
- viii. The Radiation Safety Officer will determine whether animal care personnel need radiation dosimeters, whether the animal quarters should be a Restricted Area, and whether any other precautions must be taken.
- ix. The Authorized User is responsible for ensuring that laboratories containing animals with internally deposited radionuclides are locked or otherwise secured when not attended by the Authorized User or their Qualified User.
- x. Animals containing radioactivity may not leave the institution except as specifically authorized by the RSO on a case-by-case basis.

**d) Animals and Radioactive Materials: Rules and Procedures for Animal Caretakers**

All cages bearing the tag or label "CAUTION RADIOACTIVE MATERIALS" and the radiation trefoil symbol should be treated according to the following procedures:

i. Personal Protection

- Wear radiation dosimetry as directed. However, radiation dosimeters are not used for some types of radioactivity, specifically low-energy beta emitters.
- Always wear disposable gloves, lab coats, or other protective clothing. Do not allow animals, waste, cages, etc., to touch bare skin.
- Wash hands and skin before eating, drinking, etc. If you become personally contaminated, immediately notify the Radiation Safety Officer.

ii. Routine Operations

- Unless otherwise specified, feeding and watering may be carried out as with other animals.
- Absorbent pads, urine, feces, and other waste should be placed in containers provided by Radiation Safety, not in ordinary waste receptacles. These are usually metal waste containers marked "CAUTION RADIOACTIVE MATERIALS." When a container is nearly full, call Radiation Safety for disposal.
- Cages must be treated as contaminated until washed. Radiation warning tags should not be removed until the cage has been cleaned.
- The Authorized User must check cages and rooms before release for unrestricted use. If there are any questions, the supervisor may request Radiation Safety assistance.
- When animals are transferred to clean cages, be sure the new cages are appropriately labeled.

iii. Non-Routine Operations

- For sick, dying, or dead radioactive animals, call the Authorized User, or if previous instructions have been given, follow them.
- Carcasses. Remove and save identifying tags, collars, etc. The carcass must be double-bagged and wrapped in plastic-backed absorbent pads. The outer bag cannot be contaminated and must be labeled with "Radioactive Animal Remains" and the radiation trefoil symbol. Remains must be stored in a freezer for Radiation Safety personnel to collect.

## **15. INVENTORY CONTROL FOR RADIOACTIVE MATERIALS**

### **a) General**

The Commonwealth of Virginia licenses VHS to use specific radionuclides and may possess quantities designated in the respective license. Each Authorized User at VHS can possess and use specific radionuclides in quantities specified in their permit. To ensure that neither VHS nor Authorized User limits are exceeded, the Radiation Safety Office uses the web-based SciSure inventory system that monitors radionuclides and quantities authorized and on hand for each Authorized User and the institution.

### **b) Ordering**

When Radiation Safety receives a requisition through SciSure, the user's balance is compared to their permitted quantity. If the amount on the requisition will not exceed their permitted quantity, the radionuclide is ordered. Orders are recorded on the RSO-8 "Radioactive Material Order and Receipt" and stored in the Authorized User's files.

### **c) Receipt**

When the order is received, it is checked in using steps in the RSO-8, and the RSO-9, "Radioactive Material Use and Transfer Log," is completed. The RSO-9 is given to the Authorized User to record the material's use, transfer, and disposal. The quantity received is recorded in the SciSure platform.

### **d) Disposal**

Information about radioactive waste prepared for disposal is entered on an RSO-10 "Request for Radiation Waste Collection." Activity in each waste type (solid, liquid, liquid scintillation vials and carcasses) is determined by the Authorized User and entered on the RSO-10. Activity from solid waste can be transferred from the RSO-10a "Radioactive Waste Container/Drum Contents."

### **e) Inventory**

An institutional inventory of radioactive material is conducted every six months. The SciSure platform displays "live data" that reports decayed values when produced.

### **f) Termination Inventory**

Authorized Users are required to report their inventory to Radiation Safety on an RSO-9 at least 30 days before termination to allow adequate time for transferring or disposing of radionuclides on hand.

## **16. PURCHASING RADIOACTIVE MATERIAL**

### **a) Purchasing Procedures**

- i. Only an Authorized User or their Qualified User may originate orders for radioactive material. The Radiation Safety Office places all orders for radioactive material. A radioactive materials order request must be created through the SciSure platform. To initiate the request, log in to the SciSure website and select the “*Rad Request*” page under your laboratory profile. Once on the page, you will need to submit the following information:

- Company
- Product Code
- Compound - chemical form (e.g., dATP)
- Active Isotope - (e.g., <sup>14</sup>C)
- mCi Requested (e.g., 20 mCi or 50 μCi)
- Quantity

If you need assistance  
with your order, don't  
hesitate to get in touch  
with the RSO!

- ii. The Authorized or Qualified User must complete requests at least five business days in advance.
- iii. The Radiation Safety Office will verify that *the Authorized User* may receive the requisitioned material and then enter the requisition in *the procurement platform*. Price changes, delays, or other concerns will be discussed with the individual requesting the material.
- iv. Radioactive materials must be shipped to:

Radiation Safety Office  
Virginia Health Sciences at ODU  
700 West Olney Road Lewis Hall Room 2142  
Norfolk VA 23507

- v. The RSO may modify the above procedures in case of emergency or immediate need for short-lived radioactive materials, provided all administrative, legal, record-keeping, receiving, and survey requirements are met.

### **b) Receiving Procedures**

- i. Radioactive material is received at the Radiation Safety Office, Lewis Hall Room 2142, between 9:00 a.m. and 3:30 p.m., Tuesday through Friday.
- ii. Before signing the delivery service receipt, the person receiving the package verifies that it's addressed to VHS and that the package has no visual damage. *After-hours deliveries are not accepted unless special provisions are made between the vendor, delivery service, and the Radiation Safety Officer.* If a carrier or delivery service brings a package of radioactive material after hours, it will not be accepted. If there is a problem after hours, contact the Radiation Safety Officer.

**c) Package Opening and Monitoring**

- i. All arriving radioactive packages will be surveyed within three hours of receipt.
- ii. Packages will be opened and surveyed according to 12VAC5-481-900 and good radiation safety practices. The RSO-8 "Radioactive Material Order and Receipt" form will document the receipt of all packages containing radioactive material. The RSO-8 includes information on the order that should be compared to the packing list.
- iii. Use the following procedures for packages requiring a survey:
  - Wear a lab coat and disposable gloves.
  - Visually inspect the package for physical damage. If damaged, stop and notify the RSO.
  - For all labeled (White I, Yellow II, and Yellow III) packages:
    - 1) Measure the exposure rate at 1 meter and at the surface of the package. Record these exposure rates on the RSO-8.
    - 2) Perform a wipe test on the box's exterior surfaces. Count the wipes and record the results on RSO-8.
    - 3) Remove the packing list, open the package, and verify that the contents agree with the packing list.
    - 4) Check the integrity of the inner container for signs of damage.
    - 5) Remove the inner container and wipe test its exterior surfaces. Record the assay information on the RSO-8.
  - Compare the packing list to the RSO-8 ordering information and verify the material received is the material ordered. Immediately report discrepancies to the RSO.
  - Monitor the empty package and packing materials for contamination. If contaminated, decontaminate it if feasible or discard it as radioactive waste. Remove or obliterate radiation labels and markings and discard.
  - Return the radioactive material to the shipping container.
  - Complete information on an RSO-9 "Radioactive Material Use and Transfer" for each radionuclide ordered. Calculate the activity received based on the assay date of the stock vial and enter it on the RSO-9.
  - Deliver the package to the Authorized or Qualified User, along with the RSO-8 and RSO-9. Have the user sign for the material on the RSO-8, leave the RSO-9 with the user, and return the RSO-8 to the Radiation Safety Office, for records retention.

*If problems arise anywhere during these procedures,  
stop and contact the RSO!*

## **17. TRANSFER AND TRANSPORT OF RADIOACTIVE MATERIAL**

### **a) General**

The radiation safety officer must approve the transfer of radioactive materials, either within VHS or to individuals or institutions outside of VHS, before it occurs.

- i. Transfer within VHS. Regardless of quantity, radioactive material transfer can occur only between Authorized Users for that radionuclide and only with prior RSO approval. After transfer, the total amount cannot exceed the user's permit limits. Complete the transfer section of the RSO-9 "Radioactive Material Use and Transfer" form and contact the Radiation Safety Office for approval. The RSO will manage packaging requirements.
- ii. Transfer outside of VHS. The RSO will perform all transfers of radioactive material to individuals or institutions outside of VHS. Federal and state regulations require license verifications, special packaging and labeling, and record-keeping, which the RSO must manage. Department of Transportation (DOT) regulations require specific shipping procedures for hazardous materials. The Authorized User will be responsible for all costs.

#### **Transfers of Radioactive Materials**

- Small, "license-exempt," or "general license" quantities of radioactive material must be treated the same as larger quantities, in accordance with 12VAC5-481: Part IV, 420 and 430

### **b) Transport**

- i. The transport of radioactive materials is divided into several classes. Materials producing external radiation shall be shielded to keep radiation levels ALARA.
  - For transport BETWEEN ROOMS in the same building, precautions shall be taken to minimize the possibility of spills or releases. Still, no special packaging is required as long as an Authorized or Qualified User accompanies the material.
  - Cargo elevators shall be used for transport between floors in the same building.
  - For foot transport BETWEEN BUILDINGS, radioactive materials shall be shielded as above and packed to minimize the possibility of spills or releases if the package is dropped. Utilizing secondary containment and cart transport reduces the potential for radioactive material spills. Special care shall be exercised when crossing streets.
  - For vehicle transport, radioactive materials must be shielded as above and packaged according to Department of Transportation specifications, regardless of distance.

If needed, contact the Radiation Safety Officer for more information.

## **18. HUMAN USE OF RADIOACTIVE MATERIALS**

VHS is not licensed to use radioactive materials in human diagnostic, therapeutic, or research applications. *In vitro* laboratory procedures used in research involving biological materials of human origin are not human use.

## **19. RADIATION PRODUCING MACHINES - RESPONSIBILITIES**

### **a) Supervisor**

The supervisor of any radiation-producing machine is responsible for:

- i. Providing written operating, safety, and emergency procedures for the unit.
- ii. Ensure that personnel are aware of and follow proper equipment use procedures and the radiation hazards associated with their operation.
- iii. Notify the Radiation Safety Office when there is any change in the setup, such as new equipment installed, changes in shielding, changes in radiation output, or changes in the unit's usage.
- iv. Posting the Virginia Health Department NOTICE TO EMPLOYEES (RH-F-12) and maintaining an X-ray Operators List (RH-F-31).

### **b) Operator**

The operator of a radiation-producing machine is responsible for:

- i. Following and complying with all operating, safety, and emergency procedures.
- ii. Wearing appropriate monitoring devices. Always wear an assigned radiation dosimeter when operating the unit. The dosimeter shall be worn outside the apron at the neckline whenever protective lead aprons are worn. In addition, wrist or ring dosimeters shall be worn if the unprotected hands and forearms must come near the beam.
- iii. Keeping all exposures ALARA. Operators shall never expose themselves to the useful beam and shall not stand within one meter of the tube or target while the unit is in operation unless adequately shielded. Personnel shall make full use of protective barriers, lead aprons, and gloves.
- iv. Clearing the area of non-essential personnel.
- v. Observing any restrictions on the use of the unit.
- vi. Using minimum exposure factors. Fluoroscopic work shall be performed in the minimum time possible using the lowest exposure rate and smallest aperture consistent with experimental requirements.
- vii. Notifying the supervisor and the Radiation Safety Office immediately of any accidental radiation exposure.
- viii. Keeping the unit disconnected or locked when not in actual use.
- ix. Remaining familiar with standards for radiation protection.

## **20. POLICIES AND PROCEDURES FOR RADIATION-PRODUCING MACHINES AND AREAS**

### **a) General**

Individuals proposing to use radiation-producing machines must have the Radiation Safety Committee's authorization before acquiring the equipment.

### **b) Policies**

- i. All operators of radiation-producing machines and personnel in the immediate area must wear a radiation dosimeter.
- ii. All areas where radiation-producing machines are operated shall be posted with the characteristic radiation trefoil warning sign.
- iii. The Radiation Safety Officer shall discuss and approve the structural shielding requirements of any new installation or an existing unit in which changes are contemplated.
- iv. After every change that might increase the radiation hazard, a radiation survey shall be conducted on new installations and existing units, such as replacing X-ray tubes or changing installed filtration.
- v. Unless measurements indicate they are unnecessary, the operator and all other persons in the room or area shall wear a protective apron.
- vi. Periodic surveys of radiation-producing machines shall be conducted to confirm that the equipment complies with Federal and State requirements.

### **c) Procedures**

When operating portable X-ray and fluoroscopic units:

- i. The operator shall stand as far as possible from the tube (at least six feet) and be subject during the exposure. The operator shall wear a protective apron or step behind an adequate barrier.
- ii. The operator shall not take more than 5,000 mA-seconds of exposure during any week. For greater workloads, rotation of operators or the use of portable shields is recommended.
- iii. The hand of the fluoroscopist, either with or without gloves, shall never be placed in the useful beam unless the subject attenuates the beam.
- iv. No person shall regularly be employed to hold animals during exposure. Restraint apparatus shall be designed to protect animal welfare and obtain the desired images.
- v. If reliance on the safe use of the unit depends upon mechanical restriction of the orientation of the radiation beam and limitations (voltage, current, time, permanent filtration, and maximum aperture) in the unit's output. Then, this restriction shall be rigidly adhered to.
- vi. Shutter mechanisms and interlocking devices shall not be tampered with and shall be inspected frequently to ensure proper operation.

- vii. Lead aprons, gloves, and personal protective equipment shall be inspected for deterioration at yearly intervals.
- viii. Equipment found compromised shall not be used.
- ix. A manually reset cumulative timing device shall indicate elapsed time or turn off the apparatus when the total exposure reaches a specific previously determined limit.

## **Appendix A - Emergency Procedures**

### **a) General Principles**

Incidents involving the spill or release of radioactive material include a wide range of possibilities, ranging from a minor spill to a major situation involving injury, radiation exposure or contamination to personnel, fire or explosion, and theft. While procedures are somewhat specific, they cannot address all conditions, and general safety principles always apply.

The Radiation Safety Office will complete an incident report for each reported incident involving radioactive material. The report will state the cause of the incident, include monitoring results, and describe corrective actions taken to prevent a recurrence. The Office will also determine if a report to external agencies is necessary and, if so, prepare and submit it. Radiation Safety will also assist with personnel decontamination and determine the need for additional decontamination methods and bioassays.

#### **General Safety Principles**

- Human health and safety is paramount. Radiation exposure must be minimized; however, do not delay emergency extraction or care due to presence of contamination or radiation fields.
- Containment of the radioactive material or radiation source is imperative to reduce the likelihood of further exposure or contamination.
- Notify emergency personnel such as Public Safety, Fire Department, Emergency Medical Services and Radiation Safety staff, as needed.
- Protect property and the facility from further fire, explosion or other damage.
- Record key information about the event such as who, where, what radionuclide, how much, etc.

### **b) Minor Spill Involving No Radiation Hazard to Personnel**

- i. Immediately notify others in the area.
- ii. Cover the spill with absorbent material (paper towels, disposable pads, etc.). Wear personal protective equipment (lab coat and gloves) and clean up the spill using the absorbent material.
- iii. Place the absorbent material in a labeled poly bag for transfer to a radioactive waste container.
- iv. Place contaminated gloves and other disposable material in the waste bag.
- v. Survey the area with an appropriate low-range detector or another technique, such as a wipe test, for a spill containing  $^3\text{H}$ . Survey adjacent areas, such as the hallway and door entry, for the potential spread of contamination. Monitor hands, feet, and clothing for contamination.
- vi. Report the incident to Radiation Safety promptly.
- vii. Cooperate with Radiation Safety (e.g., investigation and additional samples or decontamination).
- viii. Follow Radiation Safety instructions regarding decontamination, surveys, bioassays, and documentation.

**c) Major Spill**

Notify others in the area of the spill and instruct them to vacate the area but remain nearby to monitor and prevent the spread of contamination.

- i. Cover the spill with absorbent material (dampened material for solids), but do not attempt to clean it up at this time.

*NOTE: If the spill involves dust, mist, organic vapors, or gases, shut down the ventilation if possible unless it will be used to clear the room air. Promptly notify the RSO of suspected ingestion or inhalation.*

- ii. Shield the source if it can be done without further contamination or significant radiation exposure.
- iii. If the spill is on the skin, flush thoroughly with water. If it is on clothing, remove and discard it immediately. If necessary, take an emergency shower.
- iv. Secure the room or area and prohibit anyone from entering until Radiation Safety arrives. Notify Radiation Safety or Public Safety immediately.
- v. Radiation Safety will monitor all personnel that may have been contaminated and will supervise the clean-up. Permit no one to leave the area until allowed by the Radiation Safety Officer.
- vi. Cooperate with Radiation Safety (e.g., investigation and additional samples or decontamination).
- vii. Follow Radiation Safety instructions regarding decontamination, surveys, bioassays, and documentation).

**d) Minor Fire**

- i. In case of minor fire, such as a fire in a beaker or on the bench, attempt to put it out by smothering or using a fire extinguisher.
- ii. Notify others in the area to vacate and instruct a coworker to notify Public Safety at 446-5199 and Radiation Safety immediately.
- iii. When the fire is out, secure the area to prevent the spread of contamination.
- iv. Monitor personnel involved in firefighting for contamination and decontaminate as needed by removing contaminated clothing, flushing contaminated skin with lukewarm water, and washing with mild soap.
- v. Consult with the RSO and develop a plan to decontaminate the area.
- vi. Allow no one to return to work in the area unless the RSO approves.
- vii. Cooperate with Radiation Safety (e.g., investigation and additional samples or decontamination).
- viii. Follow Radiation Safety instructions regarding decontamination, surveys, bioassays, and documentation).

**e) Major Incident Involving Fire, Explosion, or Other Major Event**

- i. Notify all personnel in the area to vacate immediately.
- ii. Call 9-911 or activate a fire alarm pull box in the hallway. Notify Public Safety at 446-5199 and Radiation Safety at 446-5798.

**NOTE:** *In event of injury, assist the injured from the area to await medical assistance. Administer first aid as necessary.*

- iii. When emergency personnel arrive, inform them where the radioactive materials are stored or where radionuclides were used and the radionuclide involved. Also, advise them of the best possible entrance route to the restricted area and other potential risks, such as water-reactive chemicals.
- iv. In conjunction with Radiation Safety, assist emergency personnel in establishing a control point to monitor personnel leaving the area after controlling the emergency. Also, assist with contamination surveys of emergency personnel and equipment.
- v. The RSO will supervise the area's decontamination. Depending on the extent of contamination, the RSO may prescribe bioassays or other types of surveys.
- vi. Cooperate with Radiation Safety (e.g., investigation and additional samples or decontamination).
- vii. Follow Radiation Safety instructions regarding decontamination, surveys, bioassays, and documentation.

**f) Accidents Involving Airborne Radioactivity**

- i. Notify all other persons to vacate the room immediately.
- ii. Vacate the room.
- iii. If radioactive contamination is on the skin, flush thoroughly with water. If the contamination is on clothing, discard outer clothing immediately. If necessary, use an emergency shower. If there are injuries, see Injuries below.
- iv. See Decontamination of Personnel below.
- v. Notify Public Safety. Public Safety will contact Radiation Safety. Tell the Public Safety Office about the nature of the injuries, identify the radionuclides and activity involved, and provide any other pertinent information.
- vi. Make sure all access doors to the room are closed and locked. If necessary, post security guards to prevent accidental opening of doors.
- vii. Radiation Safety personnel will monitor all persons involved for bodily contamination and will direct cleanup and decontamination.
- viii. Permit no one to enter or leave the area until Radiation Safety approval is secured.

**g) Injuries to Personnel Involving Contamination**

- i. Make every effort to rescue injured and trapped persons and remove them from the incident area.
- ii. Call Security. They will call for Emergency Medical Services and the Radiation Safety Office.
- iii. Unless given by a physician or emergency medical technician, first aid should be limited to those persons where it is necessary to save life or minimize injury.
- iv. Wash minor wounds immediately under running water while spreading the edges of the laceration.
- v. Remove and save all articles of contaminated clothing, jewelry, etc.
- vi. No person involved in a radiation injury may return to work or leave the premises without the approval of Radiation Safety personnel *or a physician*.
- vii. When it is necessary to send an individual to a hospital or other medical facility before a radiological emergency team or a physician knowledgeable in radiological health arrives, inform ambulance personnel, who will contact any injured individual of the possibility of radioactive contamination. Also, inform the hospital or medical facility that the individual may be contaminated with radioactive material.

**h) Decontamination of Personnel**

- i. External Contamination

External contamination on the person may:

- Cause injury from local exposure of the skin.
- Penetrate the intact skin (especially in the presence of certain organic solvents).
- Eventually, it can be transferred into the body by ingestion or inhalation.

Radioactive material entering the body by inhalation or ingestion is a significant concern; therefore, decontamination procedures primarily reduce the likelihood of inhalation or ingestion.

As a rule, except for hand decontamination or in cases of emergency as agreed upon by the Radiation Safety Officer, all mild decontaminating procedures described below should be carried out under the Officer's supervision. Attempts to remove contamination that resists mild procedures should only be made under medical supervision.

Immediate washing of contaminated areas with water and soap is the method of choice for removing loose contamination, subject to certain elementary precautions:

- Tepid water, not too hot, should be used.
- Soap should not be abrasive or highly alkaline.
- Washing should be performed by scrubbing with a soft brush only so as not to abrade the skin.
- The skin should be washed for a few minutes at a time, then dried and monitored.

Repeat washing if necessary (as indicated by monitoring), providing no indication of skin damage.

If this procedure fails, only a mild detergent approved by the Radiation Safety Office may be used. However, repeated applications of detergents to the same area of the skin, such as hands, might injure the skin and make it permeable.

**THE USE OF ORGANIC SOLVENTS OR ACIDIC OR ALKALINE SOLUTIONS SHOULD BE AVOIDED**

Proper decontamination of creases, folds, hair, and parts of the hands, such as fingernails, the inter-finger space, and the outer edges, should be given special attention.

Care should be taken to prevent contamination from spreading to uncontaminated areas and to avoid internal contamination. If there is a risk of such a spread, an attempt should first be made to remove the contamination locally with absorbent material and, if necessary, properly mask the adjacent non-contaminated areas of the skin. A non-contaminated open wound should be protected.

After each decontamination process, the treated area should be dried with a fresh, non-contaminated towel or swab and then monitored. All towels and swabs used in decontamination should be treated as contaminated material and placed in a labeled waste bag.

When decontaminating the face, special care should be taken to prevent contamination of the eyes, nasal passages, or lips.

Attempts to remove contamination that resists washing should only be made under medical supervision.

ii. Internal Contamination

Radioactive contamination of personnel can be internalized through:

- Ingestion
- Inhalation
- Wounds or
- Skin penetration

If internal contamination is suspected during regular working hours, it should be immediately reported to the Radiation Safety Officer or VHS Public Safety.

Internal contamination is a medical problem similar in some ways to the absorption of chemical toxins. Therefore, special procedures should be conducted under medical supervision.

Aims of the corrective procedures are: (a) to eliminate as much of the internally introduced contaminant remaining in the mouth and gastrointestinal or respiratory tract as quickly as possible and try to prevent or reduce its uptake into the bloodstream and tissues; (b) to prevent fixation of the contaminant in the body or try to increase its excretion from the body.

For the first of these aims, it is sometimes necessary for the contaminated person or another non-medical person to take immediate action (in the first seconds or

minutes), for instance, to promote the mechanical elimination of the contaminant through vomiting or expectoration.

In case of contaminated minor open wounds, cuts, punctures, or other injuries, the wound should be immediately washed, bleeding encouraged if necessary, and referred to a physician.

For the second of the aims indicated above, any further procedure of internal decontamination, e.g., more complicated chemical or physical-chemical methods, is a matter of medical treatment. It should be undertaken as soon as possible but only under medical supervision.

**i) Loss or Theft of Radioactive Materials**

In case of loss or theft of radioactive materials or suspected loss or theft, contact VHS Police and Public Safety immediately. Ask them to contact Environmental Health and Safety.

**j) Supplement to Radiation Emergency Procedures for Police and Public Safety Officers**

- i. Upon receiving an emergency call, the Police and Public Safety Officer should collect the following information: the location and time of the incident, the nature of the incident, whether fire or medical assistance is needed, the name and telephone number of the caller, and the type and quantity of radioactive material involved.
- ii. An officer should be sent to the incident scene to assist with and control entry and exit from the area. No one is permitted to leave unless a trained person has monitored them for radioactive contamination. Do not eat, drink, or smoke in the incident area or consume food or drink. Do not handle, use, or remove from the incident area any material, equipment, or other items suspected to be contaminated unless released by Radiation Safety personnel.
- iii. The Public Safety Dispatcher should summon emergency fire or medical assistance as needed.
- iv. Contact the Radiation Safety Officer, Assistant Radiation Safety Officer, or a Radiation Safety Committee member using the following phone priority list:
  - Radiation Safety Office: 446-5798
  - Radiation Safety Officer via Public Safety: 446-5199
  - Chairman, Radiation Safety Committee via Public Safety: 446-5199
  - The faculty member is responsible for the laboratory.
  - If none of the above can be reached, and only in a dire emergency, such as when radioactive material is accidentally released from the building or there's been an explosion and fire involving radioactive material, contact the Radiological Health Section, Virginia Department of Health (804) 864-8150 or Department of Emergency Services 800-523-6019.
- v. When they reach the scene of an incident, Police and Public Safety Officers should help determine whether injured persons need emergency care and take steps to provide it.
- vi. When a transportation incident involves radioactive material, do not move vehicles, shipping containers, or wreckage except to rescue the victim(s): detour pedestrians and vehicular traffic. If a right-of-way must be cleared before radiological assistance arrives, move vehicles and debris the shortest distance required to open a pathway. Before

permitting the passage of traffic, spillage on the cleared pathway should be washed to the path's edge to minimize the spilled material's dispersal.

**k) Incident Reporting to Press and Public**

Because of concern about radiation on the part of the media and non-scientific public, it is the policy of the Radiation Safety Committee that all releases to the press and public are made by VHS Marketing & Communications. No other person is authorized to speak on behalf of VHS. Contact VHS Marketing & Communications at 757-446-7070.

**l) Supplement to Emergency Procedures for Radiation Safety Personnel**

**i. Procedures for Receiving Notification of an Accident**

- ❑ Upon receiving a call, Radiation Safety personnel should collect the following information: location of the accident, number of injured persons, brief indication of the type of radiation exposure involved, and name and telephone number of the individual reporting the accident.
- ❑ Dispatch a person from the Radiation Safety Office or a member of the Radiation Safety Committee to the accident location as quickly as possible.
- ❑ Suppose the accident appears to be of such magnitude that it must be reported to the NRC or the Virginia Department of Health. In that case, Radiation Safety personnel shall initiate the collection of appropriate information and notify Security for documentation purposes. Radiation Safety will prepare the report, obtain appropriate clearances, and submit it.
- ❑ Arrange for medical examinations for all individuals who may have received exposure of the whole body to 25 rems or more of radiation; exposure of the feet, ankles, hands, or forearms to 375 rems or more of radiation; or exposure to released radioactive material in concentrations which, if averaged over 24 hours, would exceed 5000 times the limit specified for such material in 12VAC5-481-3690.

**ii. Procedures for Accident Involving Release of Radioactive Material**

- ❑ Determine the types and amount of radioactive material involved.
- ❑ Remove individuals from contaminated areas and take steps to minimize the spread of contamination. Save all items of contaminated clothing, personal effects, etc.
- ❑ Obtain the complete names, addresses, and contact information of all individuals involved in the accident. Keep them at the scene until all necessary information is obtained.
- ❑ Start survey operations to establish the magnitude of possible exposure to the individuals involved.
- ❑ Start a survey of contamination levels and record the results on a diagram of the lab or area. Also, record the make and model of the survey instrument and detector.

**iii. Procedure for Accidents Involving Overexposure to External Sources of Ionizing Radiation**

- ❑ Obtain the names of all individuals involved in the accident.

- Check radiation levels in areas accessible to personnel to avoid the risk of further exposure to any individuals, including Radiation Safety personnel.
- Start measurements designed to quantify the extent of radiation exposure to individuals involved and record exposure rates on a diagram of the area.

## **Appendix B - Radiation Protection Terms**

**Absorbed Dose (D):** Energy imparted to matter by ionizing radiation per unit mass of irradiated material. The SI unit of absorbed dose is the Gray (Gy); the conventional unit is the RAD. One Gray equals one joule per kilogram.

**Activity:** The number of nuclear transformations occurring in a given quantity of radioactive material per unit mass (See Becquerel and Curie).

**Alpha Particle:** A positively charged particle emitted from the nucleus of an atom with a mass equal to a helium nucleus (two protons and two neutrons).

**Atomic Mass:** The sum of neutrons and protons in the nucleus.

**Atomic Number:** The number of protons in the nucleus ( $Z$ ).

**Becquerel:** The SI unit for activity. One Bq =  $1 \text{ s}^{-1}$  or one transformation per second.

**Beta Particle:** Charged particle emitted from the nucleus of an atom with mass and charge equal to an electron.

**Bremsstrahlung:** Secondary photon radiation produced by deceleration of charged particles passing through matter.

**Committed Dose Equivalent ( $H_{T,50}$ ):** Dose equivalent to organs or tissues that an individual will receive from an intake of radioactive material during the 50-year period following the intake.

**Committed Effective Dose Equivalent ( $H_{E,50}$ )** The sum of the products of weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to those organs or tissues.

**Counts Per Minute (CPM):** The external indication of a device that detects radiation. It refers to the total number of events the detector registers in one minute.

**Curie (Ci):** A unit of activity. One curie =  $3.7 \times 10^{10}$  nuclear transformations per second.

**Decay Constant (DC):** The fraction of the number of atoms of a radioactive nuclide that decay in unit time.

**Deep Dose Equivalent (DDE,  $H_D$ ):** This applies to external whole-body exposure; dose equivalent at 1 cm ( $1000 \text{ mg/cm}^2$ ) depth.

**Disintegrations Per Minute (DPM):** Number of nuclear transformations per minute, taking into account the yield of the detection system.  $\text{DPM} = \text{CPM}/Y$ .

**Dose Equivalent (H):** The product of the absorbed dose in gray or rad and the quality factor ( $Q$ ). Expressed in Sievert (Sv) =  $D(\text{Gy}) \times Q$  or Rem =  $D(\text{RAD}) \times Q$  for radiation protection purposes.

**Effective Dose Equivalent ( $H_E$ ):** Sum of the products of the dose equivalent to the organ and tissue and the weighting factor ( $w_T$ ) applicable to each body organ or irradiated tissue.

**Electron Volt (eV):** A unit of energy equivalent to the energy gained by an electron passing through a potential difference of one volt, used to express the energy of nuclear radiation, such  $\text{keV} = 10^3 \text{ eV}$  or  $\text{MeV} = 10^6 \text{ eV}$ . One eV =  $1.6 \times 10^{-19} \text{ erg}$ .

**Exposure:** A measure of ionization produced in a volume of air by x-ray or gamma radiation. The special unit is roentgen, which equals one statcoulomb charge per cubic centimeter of air.

**Gamma Ray:** Short wavelength electromagnetic radiation emitted from the nucleus from 10 keV to 9 MeV.

**Geiger Counter:** An ionizing radiation detector in which the charge collected per ionizing event is independent of the number of ions produced in the initial ionizing event.

**Gray (Gy):** The absorbed dose's SI unit equals 1 Joule /kg.

**Half-Life, Biological (T<sub>B</sub>):** The time required for the body to eliminate one-half of the quantity of material inhaled or ingested by normal physiological processes.

**Half-Life, Effective (T<sub>E</sub>):** The time required for a radioactive element in the body to be reduced by one-half due to radioactive decay and biological elimination.

**Half-Life, Radioactive (T<sub>P</sub>):** The time required for a radioactive element to decay to one-half of its activity by nuclear transformations.

**Ionization:** The process by which a neutral atom or molecule acquires a positive or negative charge.

**Irradiation:** Exposure to radiation.

**Isotope:** A radionuclide that contains the same number of protons and a different number of neutrons in the nucleus. The atomic number (Z) is the same, but the atomic mass (A) is different.

**Joule:** A unit of energy that equals one Newton·Meter.

**Monitoring:** Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination in an area.

**Nuclide:** A species of atom characterized by the constitution of its nucleus. The number of protons (Z), neutrons, and energy content specifies the nuclear constitution.

**Photon:** A quantity of electromagnetic energy (joules) that is the product of frequency (f) in hertz and Planks constant (h).  $E = hf$ .

**Quality Factor (Q):** The linear energy transfer dependent factor by which absorbed doses are multiplied to obtain a quantity that expresses the effectiveness of absorbed radiation.

**RAD:** Radiation Absorbed Dose equal to 0.01 Joule/kg. 100 RAD = 1 Gray.

**Radiation:** The emission and propagation of energy through space or materials, such as alpha, beta and gamma radiation.

**Radioactivity:** The property of nuclides to spontaneously emit particles or gamma radiation or emitting x-rays following orbital electron capture or spontaneous fission.

**Shallow Dose Equivalent (H<sub>s</sub>):** External exposure to the skin or extremity; dose equivalent at 0.007 cm (7 mg/cm<sup>2</sup>) depth.

**Sievert (Sv):** The SI unit for dose equivalent that is the product of the absorbed dose in Gray times the Quality factor.

**Specific Activity:** Activity per gram of a compound, element or radioactive material.

**Survey (Radioactive):** Evaluation of the radiation hazards associated with the production, use or existence of radioactive materials or other radiation sources under specific conditions.

**Total Effective Dose Equivalent (TEDE):** The sum of the deep and committed doses equivalent.

**Transformation:** Emission of energy from the nucleus to achieve a favorable neutron-to-gamma ratio and nuclear stability. Emitted energy may be in the form of alpha, beta, gamma, or neutron radiation.

**Weighting Factor ( $w_T$ ):** The proportion of the risk of stochastic effect resulting from that organ or tissue irradiation to the total risk of stochastic effects when the whole body is irradiated uniformly.

**X-ray:** Electromagnetic radiation originating outside the nucleus due to electron transitions with a wavelength shorter than visible light.

## **Appendix C - Procedures for Identifying and Reporting Defects**

- a) Defects are defined as deviations in essential components that, based on an evaluation, could create a substantial safety hazard involving radioactive material. A substantial safety hazard means the loss of a safety function to the extent that there is a major reduction in the degree of public health and safety protection. For VHS, there is a potential for moderate personal exposure to or release of licensed material.
  - i. Moderate exposure is considered: 1) greater than 25 rem total effective dose equivalent to occupationally exposed workers in a year or less, or 2) exposure  $\geq 0.5$  rem to an individual in an unrestricted area in a year or less.
  - ii. The potential release of the licensed material is a release of a reportable amount, or loss or theft, in accordance with 12VAC5-481-1090, 12VAC5-481-1100, or 12VAC5-481-1110.
- b) Employees shall:
  - i. Identify defects in products containing radioactive material received from vendors and promptly report the defect to the Radiation Safety Officer.
- c) The Radiation Safety Officer shall inform the Chairman of the Radiation Safety Committee, who will cause the deviation to be evaluated and reported in writing to the Radiation Safety Committee. An Ad-hoc committee will be constituted from the Radiation Safety Committee membership.
  - i. If the evaluation determines that a defect exists, the Radiation Safety Officer will initially report by facsimile to the NRC Operations Center at 301-816-5151 or by telephone at 301-816-5100 within two days of receiving information from the Chairman of the radiation Safety Committee on the identification of a defect or failure to comply.
  - ii. A written report will be prepared by the Radiation Safety Officer for submission to the NRC within 30 days following receipt of information from the Chairman of the Radiation Safety Committee on the identification of the defect.
- d) The report will include the information specified in 12VAC5-481-1090, 12VAC5-481-1100, 12VAC5-481-1150, 12VAC5-481-1330, and 12VAC5-481-1530.

## **Appendix D - Forms**

- RSO-01 Application for User Status
- RSO-01a AU Approval
- RSO-01b QU Approval
- RSO-01c Authorization Expiration
- RSO-02 Application for Possession and Use
- RSO-04 Application for Rad Device
- RSO-05 Periodic Contamination Survey Exemption
- RSO-06 AU Termination Notice
- RSO-07 Radiation Safety Closeout Survey
- RSO-07a Laboratory Closeout Checklist
- RSO-07b Laboratory Decommission Letter
- RSO-08 Radioactive Material Order and Receipt
- RSO-09 Radioactive Material Use and Transfer
- RSO-10 Waste Pickup
- RSO-10a Radioactive Waste Container Contents
- RSO-10b Decay-in-Storage Disposal
- RSO-11 Semi-Annual Inventory
- RSO-12 Survey Instrument Calibration
- RSO-13 Radiation Survey Form
- RSO-14 Incident Report
- RSO-15 Corrective Action Protocol
- RSO-16 Request for Dosimetry
- RSO-16a Request for Personnel Dosimetry History
- RSO-17 Request for Dosimetry - Spare Badge
- RSO-18 Prenatal Instructions
- RSO-18a Declaration of Pregnancy
- RSO-19 Lost Dosimeter
- RSO-20 Annual Dose Report
- RSO-21 Radiation Exposure Notice.
- RSO-22 Iodination Safety Checklist