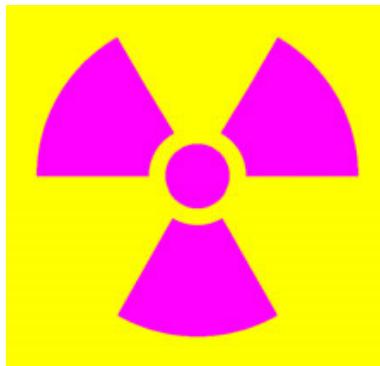


RADIATION SAFETY MANUAL



AUGUST 2016

Environmental Health and Safety

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FOREWORD

The Radiation Safety Manual represents one part of a commitment by the administration of the Eastern Virginia Medical School (EVMS) to keep occupational radiation exposures as low as reasonably achievable (ALARA). While radiation exposure to patients in the healing arts has demonstrated a large benefit-to-risk ratio for both diagnosis and therapy, there is widespread agreement among physicians, scientists, and regulatory agencies that occupational exposures should be minimized as far as is practical.

EVMS has created, staffed, and equipped a Radiation Safety Office, within the Department of Environmental Health and Safety, to oversee the use of radioactive material in research. EVMS is committed to adequately training investigators using radioactive material and to supporting the staff of the Radiation Safety Office in their efforts to assure 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, and to equipment and facilities, will be considered where they will substantially reduce radiation exposures at reasonable cost.

INTRODUCTION

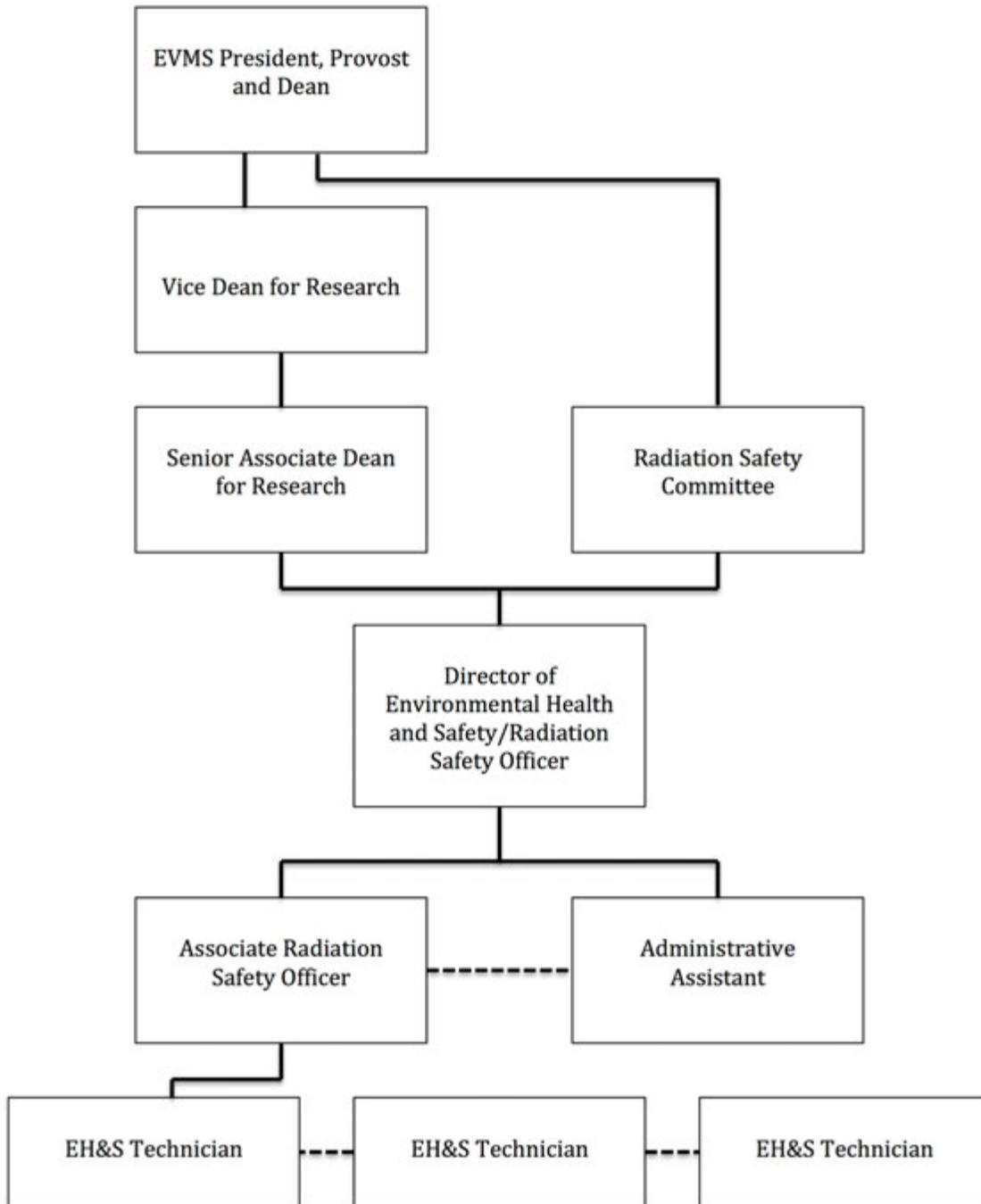
With the use of radioactive materials and radiation producing machines, it is imperative that these materials be used in a manner to minimize radiation exposure to personnel and the environment. EVMS operates within regulations issued by the Commonwealth of Virginia (Radiation Protection Regulations, Chapter 481 of the Virginia Administrative Code). These regulations constitute minimum requirements for maintaining a safe and productive workplace. The general policy of the Eastern Virginia Medical School is to keep radiation exposure ALARA.

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

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

1. ORGANIZATIONAL CHART

The administrative structure to supervise the possession of radiation sources and their use within EVMS is shown below. For details concerning these relationships, see sections, 2, 3, 4 and 6.



2. RADIATION SAFETY COMMITTEE

a) General Description

The RSC shall be a standing committee of EVMS. The RSC shall be appointed by the Dean, and consist of at least the Senior Associate Dean for Research, the Radiation Safety Officer (RSO), two or more faculty members engaged in work with radioactive material and one full-time laboratory technician who is involved in the routine use of radioactive materials. The Senior Associate Dean for Research, the RSO and the technician will not be eligible to serve as permanent Chairman of the Committee. The RSC shall meet at least quarterly and upon call of the Chairman. A quorum shall consist of four members, three of whom must be the Chairman or Vice Chairman, the Radiation Safety Officer or Associate Radiation Safety Officer and the Administrative Representative or alternate.

Application to use radioactive material is made on forms to the RSC. The Chairman, the RSO and at least two other RSC members review the applications. Criteria are established for approving new users and uses of radioactive material. The RSC has the sole responsibility for the possession and use of radioactive materials and sources of radiation. The RSC is the final authority within EVMS in all matters pertaining to the establishment and administration of the Radiation Safety program. This Committee has been designated by the Virginia Department of Health, Division of Radiological Health, as the responsible agent for EVMS. Curricula vitae for RSC members shall be kept on file in the Radiation Safety Office.

b) Duties and Functions

The duties and functions of the RSC are to:

- i. Establish rules, regulations, policies and overall guidance regarding EVMS 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 prior to 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 use of radioactive materials or safety rules established by the Radiation Safety Office. The review will include analysis of the cause, corrective actions and actions to prevent recurrence.
- viii. Report annually to the EVMS 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 his/her designate.
- ii. Call for meetings of the RSC.
- iii. Circulate minutes of the RSC meetings to other committees with responsibility in the area of biosafety or hazardous chemicals, and to establish coordination 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, EVMS, and who by reason 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 a member of 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.

It is the policy of the Radiation Safety Committee that the Radiation Safety Officer and other Radiation Safety personnel to provide radiation protection service to the EVMS community. This service extends from health and safety functions through legal and administration duties, to the procurement, use and disposal of radioactive materials and other sources of radiation. A Radiation Safety Office is established to provide these services.

The Radiation Safety Officer reports to the Senior Associate Dean of Research for administrative purposes and to the Radiation Safety Committee for matters pertaining to 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 the use, storage, or disposal of radioactive material.
- iii. Packaging, labeling, surveys, etc., of all shipments of radioactive material leaving the licensed facilities.
- iv. Personnel monitoring program, including determining the need for and evaluating bioassays, monitoring personnel exposure records and developing corrective actions for exposures approaching maximum permissible limits.
- 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 of inventory of radioactive materials at EVMS.
- 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 confiscation of radioactive material, if such actions would remove or prevent the recurrence of a threat 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 OF RADIOACTIVE MATERIALS AND RADIATION PRODUCING MACHINES

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" and "Restricted User." A discussion of each category including the particular responsibilities and authorizations follows.

A chain of responsibility regarding the safe use of radioactive material and radiation producing machines exists from individual users to the RSC. This chain is independent of other administrative lines of control within EVMS. However, the RSC recognizes the right of any administrative entity within EVMS to impose additional restrictions, qualifications, and regulations regarding the use of radioactive material, radiation or equipment by persons under its control.

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 proper storage of materials under his/her control and for their proper use under his/her direction. An Authorized User may initiate purchase or transfer of radioactive materials, as described in this manual.

In general, Authorized Users should be permanent members of EVMS with significant training and experience in the use of radioactive material and would have 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 category of "Qualified User" is established to allow 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 the use of radioactive material whose association with EVMS 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 supervision of an Authorized User and may independently use radioactive material in protocols approved in the Authorized Users permit.

d) Restricted User

A "Restricted User" is one who 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 EVMS. A Restricted User may only use radioactive materials or radiation producing machines under direct supervision of an Authorized User. Authorized Users are required to notify the RSO in writing when an individual is working for them as a Restricted User. The memo should include the Restricted User's name and date they became a Restricted User.

e) Direct or Personal Supervision

- i. Direct supervision requires that the operation be planned by the Authorized User, the Restricted User has been told of potential hazards and been instructed in procedures to be followed both 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 room while the radionuclide is in use.
- iii. When the operation involves sealed source or sources which 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 must 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 is in two parts. The first part is "Training and Experience" (RSO-1 "Application for User Status") while the second part is "Possession and Use" (RSO-2 "Application for Possession and Use" *and/or* RSO-4 "Application for Radiation Device"). "Possession and Use" applications must be renewed every two years, while a "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 RSC Chairman, the Radiation Safety Officer and at least two other members of the RSC will then review the application. Between regularly scheduled meetings, review and approval will ordinarily be done 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 safely conduct the proposed use.
- ii. Possesses adequate 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 his/her 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 may be submitted indicating the desired change.

6. INDIVIDUAL RESPONSIBILITY

a) All Users

Each individual at the Eastern Virginia Medical School, regardless of category or authorization, who has contact with radioactive materials or other radiation sources is responsible to:

- i. Be familiar with the EVMS Radiation Safety Manual.
- ii. Keep his/her exposure to radiation and that of those working under his/her supervision As Low As Reasonably Achievable (ALARA), and 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 levels specified in 12VAC5-481-670.
- iii. Wear prescribed radiation dosimeters in radiation areas. Personnel who work only with alpha emitters or beta emitters having a maximum energy of less than 200 keV will not be required to wear radiation dosimeters.
- iv. Conduct precautionary personnel surveys at frequent intervals with a suitable survey instrument, according to their approved permit and maintain required records.
- v. Limit the use of their authorized 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 may audit these records at any time.
- vii. Transfer radioactive materials in accordance with this manual and all applicable regulations.
- viii. Assure that smoking, eating, drinking, and the application of cosmetics are prohibited in areas in which unsealed radioactive materials are present.

b) Authorized Users

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

- i. Adequate planning. Before an experiment is performed, the User should determine the types and amounts of radiation or radioactive material to be used. This will generally dictate the level of protection required. Procedures must be well outlined. In most cases, before the procedure is actually performed with radioactive materials, it should be rehearsed to preclude accidents or unexpected circumstances.
- ii. Being 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 EVMS 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 prior to any minors (persons under 18) engaging in activities involving radiation and radioactivity.
 - Informing the Radiation Safety Officer prior to any declared pregnant woman who may be occupationally exposed to ionizing radiation.

7. RADIATION PROTECTION PROCEDURES

The purpose of this section is to provide a safe working environment for laboratory personnel, to ensure public safety and to avoid contamination of equipment and facilities.

a) Authorized User

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

b) Rules and Procedures for Laboratory Personnel

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

c) General Rules and Procedures

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

- i. Wear a lab coat or other protective clothing at all times when working with radioactive materials. Remove and secure the lab coat within the lab before leaving the lab.
- ii. Wear non-powdered disposable gloves when handling radioactive material. Change gloves frequently to prevent the spread of contamination.
- iii. Remove gloves at 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 any area where radioactive material is used or stored.
- vi. Use mechanical pipetting devices. DO NOT PIPETTE BY MOUTH!

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 place 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 prior to and during repair work.
- iv. Place radioactive material labels on storage areas such as refrigerators, freezers or storage areas. Ensure that container with radioactive material are clearly marked with a radiation labels that identifies the radionuclide, quantity and date.
- v. Perform surveys in accordance with requirements of their approved protocols and the procedures in the “Surveys” section.

e) Personnel Monitoring and Area Monitoring

- i. If issued radiation monitoring device(s), wear it at all times when in radioactive materials storage or use areas. If the dosimeter is lost, immediately notify Radiation Safety.
- 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 inch 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

- Iodinations that use an oxidative process (such as the iodine monochloride, lactoperoxidase, and chloramine-T processes) risk releasing radioactive iodine gas to the atmosphere. In order to protect personnel and the environment, oxidative iodinations are to be done 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 should 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, 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 in performing breathing zone and environmental air sampling as deemed necessary by the RSO.
- Radiation workers involved in the iodination and preliminary purification steps will have thyroid counts performed before, and 24-96 hours 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 (NaBH₄) labeled with tritium is a useful reagent for reducing certain organic compounds and labeling them with tritium. It is very hygroscopic and hydrolyzes readily (even with humidity in the air) to release tritium gas. It is not stable in any solutions in which hydrogen ions are present, although the useful life in solution can be extended by alkalizing the solution.

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:

$$4I^- + O_2 + 4H^+ \leftarrow 2I_2(\text{gas}) + 2H_2O$$

iii. Tritium-Labeled Sodium Borohydride Procedure

Use the following procedure when using tritiated NaBH₄:

- Perform all work with the crystalline stock material or solutions in an operating hood. This includes initial unpacking, as all vials of stock material are found to contain high concentrations of radioactive gas, and weighing out of stock. When hood operations are not possible, such as during centrifugation or shaking operations, cover containers tightly with caps or two layers of paraffin film.
- Monitor all areas where NaBH₄ (³H) has been used for removable contamination by doing wipe tests and counting them in a liquid scintillation counter.
- **Do Not** mouth pipette radioactive solutions.
- Use disposable waterproof gloves in all radioactive operations, and cover work areas with plastic-backed absorbent material. Change gloves frequently.
- All liquid waste should be acidified and stored in a hood for at least 24 hours, and boiled if possible. The acidification will degrade the BH₄ 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.
- NaBH₄ (³H) should be stored in a desiccator that is to be opened only in a hood.
- The reagent will degrade more slowly if it is always kept dry. The use of 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 an essential part of a radiation safety program. Records of surveys are required by law and will be examined in each Authorized User's work area during State of Virginia, Division of Radiological Health 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 individual user.

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

- i. Fixed contamination is radioactive material that has bound with or leached into a surface and is not readily removable. This type of contamination is detected with a survey instrument able to detect the type and quantity of radioactive material present. Most common biomedical radioactive tracers can be detected with a thin window Geiger-Mueller survey instrument, with the exception of tritium.
- ii. Removable contamination is a greater potential hazard because it may be transferred from one place to another unknowingly. 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 are commonly used) 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 where the potential for exposure to external sources exist. This excludes low energy beta emitters, such as ^3H , ^{14}C , ^{33}P , ^{35}S and ^{45}Ca , but includes ^{32}P , and gamma emitting sources. G-M detectors may be used for exposure rate measurements if they have been calibrated to the energy in question. Ion chamber instruments are best for measurement of exposure rate, although they are usually an order of magnitude 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}I surveys.
- iv. Hazard evaluations will be made periodically by the RSO, 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 indicate 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 shipping containers, both incoming and outgoing. The RSO will perform a survey of each Restricted Area no less than quarterly, and other surveys as needed.

b) Periodic Survey Frequency

Authorized User survey frequency is based on the radionuclide group and activity handled at one time. To determine frequency for your lab, identify the radionuclide by Group from the Group table below then identify the amount of activity handled at one time from the Survey Frequency category table. Individuals using ^{32}P and gamma emitting radionuclides are

required to perform an instrument survey of their work area and self at the end of each procedure.

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

Survey Frequency is based on group and category:

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

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

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 performed by Environmental Health & Safety indicated that 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 used as core labs that have space or equipment used 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 Radiation Safety Officer.
- 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 kept with 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 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 of 2,000 disintegrations per minute (DPM)/100 cm² above background is established for restricted areas, and an action level of any value over background for unrestricted areas will require decontamination to be performed and completed. After decontamination, a survey is required to document its effectiveness.
- ii. To find the background value by use of a handheld detector, turn on the detector in the area being surveyed and wait a few minutes while looking at the detector window. Read the meter, which is normally be 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 cm² 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 short duration, as long as steps are taken to control the total dose equivalent within 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

Authorized Users will be required by the Radiation Safety Committee 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.)
- Instrument reads within $\pm 20\%$ of true value. Read the appropriate section of the instrument manual to determine how to make necessary adjustments to bring 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, all costs are the responsibility of the User.

ii. Sources of ^{137}Cs or ^{60}Co are appropriate for the performance of calibration. The instrument must be calibrated at lower energies if its response is *energy dependent* and it is to be used to *measure* ^{125}I , ^{133}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:

- i. Introduce pulses into circuit at connection to radiation detector. Pulses should be similar to those produced by actual ionizing events.
- ii. Adjust instrument to $\pm 20\%$ when measured at two points on each scale of the instrument (approximately $\frac{1}{3}$ and $\frac{2}{3}$ of full scale recommended). This will set the linearity on all ranges.
- iii. After linearity is set, reattach detector and use calibrated beta sources of various beta energies to determine efficiency of the instrument for each energy desired. Use long half-life beta sources as appropriate.
- iv. A plot of beta energy (maximum) versus instrument response (efficiency) can be made if desired.
- v. 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 long half-life, e.g., ^{137}Cs , shall be also 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

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

10. RADIATION DOSE LIMITS

a) General

Use of radioactive material and radiation-producing machines may result in employee exposure to radiation. Procedural and administrative radiation protection practices are developed to minimize radiation dose to employees as well as members of the general public in unrestricted areas. Application of these dose limits will ensure that individuals do not exceed levels of acceptable risk from radiation exposure. In all cases, the objective is to keep radiation dose As Low As Reasonably Achievable (ALARA).

b) Adults

Radiation dose shall be controlled such that the limits listed below are not exceeded, except in the case of planned special exposures. It is unlikely that a planned special exposure would be permitted; however, in the event planned special exposures are deemed necessary, the conditions of 12VAC5-481-690 must be met.

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

Women who declare their pregnancy are offered additional protection to their developing 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.

To declare a pregnancy, the pregnant worker must notify the Radiation Safety Officer in writing. 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 radionuclide used in her work. The declared pregnant worker will be automatically assigned a secondary abdomen dosimeter. The results of her monitoring will be reported on a monthly basis 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 as low as reasonably achievable, 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 any one hour.

f) **Internal Dose**

The majority of radionuclide manipulations at EVMS present minimal likelihood for inhalation or ingestion of radionuclides; therefore, internal occupational doses are not anticipated. In event a protocol or procedure contains a potential for an occupational intake, actions will be initiated by the Authorized User to ensure the intake doesn't exceed two percent of the Allowable Limit on Intake (ALI). Respirator 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 receives minimal radiation exposure. Most operations at EVMS 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.

EVMS Clinical ALARA Warning Levels (mrem/year)					
	<i>Level 1</i>		<i>Level 2</i>		Annual Limit
	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
EVMS Non-Clinical ALARA Warning Levels (mrem/year)					
	<i>Level 1</i>		<i>Level 2</i>		Annual Limit
	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 their work practices that led to the accumulation of dose.
- ii. Internal Exposure. Prudent use of in vivo and in vitro bioassays ensure that work practices minimize 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 that includes at least two additional bioassay measurements and a review of procedures that may have resulted in the intake.

Example: ^{125}I

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

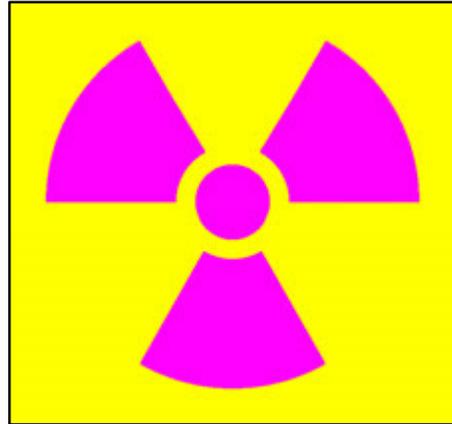
In event the intake is greater than 0.1 times ALI, a thorough investigation consisting of additional bioassay measurements will be performed to obtain sufficient data to determine excretion and retention functions and quantify the initial intake. These measurements and results will be retained permanently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

11. POSTING AND LABELING

The presence of radioactivity or radiation fields is identified by use of the standard radiation symbol, a magenta three-bladed (tre-foil) 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 in which 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 the words "GRAVE DANGER, VERY HIGH RADIATION AREA."
- ii. High Radiation Area. An area in which an individual could receive a dose equivalent in excess of 100 mrem in 1 hour at 30 centimeters (12 inches) from source. This area shall be posted with a radiation sign containing the words, "CAUTION, HIGH RADIATION AREA," or "DANGER, HIGH RADIATION AREA."
- iii. Radiation Area. An area in which an individual could receive a dose equivalent in excess of 5 mrem in 1 hour at 30 centimeters (12 inches) from the source. This area shall be posted with a radiation sign containing the words "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 ^3H , 1 mCi of ^{35}S , 0.1 mCi of ^{32}P or 0.001 mCi of ^{125}I .



b) Exceptions to Posting Signs

- i. Caution signs are not required if rooms or areas contain:
 - Radioactive material for less than eight hours per day, and the room is constantly attended 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 name of Authorized User. When the containers and equipment are free of radioactive contamination (as determined by survey) the labels should be removed or obliterated to indicate there is no longer radioactive material present.

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 ^3H , 10 μCi of ^{32}P , 100 μCi of ^{35}S and 1 μCi of ^{125}I .
- ii. Containers attended by an individual trained in radiation protection practices.

d) Restricted Area

A restricted area is an area where access is controlled 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 doses are in compliance with occupational dose limits. Monitoring may consist of dosimeters to measure external dose or bioassays to determine dose due to intake of a radionuclide. The necessity to monitor an individual is determined during review of the proposed use of radioactive material or radiation producing machines. There is a wide variety of materials and technologies that can be used for personnel dosimetry. Bioassays may be performed by assaying biological samples such as mucus, 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 limits. For minors and declared pregnant women, radiation dosimeters are issued when it's likely they may exceed 0.050 rems in a year from external sources.

i. Exchange Frequency

Radiation dosimeters (whole body, wrist or finger) are exchanged every three months for most workers. Clinical workers, including medical residents, have their dosimeters exchanged 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

EVMS EH&S is authorized to recover lost and late fees incurred by departments that do not return dosimetry in a timely manner 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 such 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 more than several months since the issue period. To obtain information for a dose estimate, the Radiation Safety Office sends a memo to the individual advising them of the loss/damage and requests that information is provided about their exposure to ionizing radiation during the period and to identify coworkers receiving similar exposure. This information, in addition to previous exposure history, is 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.

2016 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 in excess of 10 percent of the ALI's in Table 1, columns 1 and 2 of 12VAC5-481-3690. Additionally, where minors and declared pregnant women could receive in one year a committed effective dose equivalent of 0.05 rem, the intake shall be assessed by monitoring airborne contaminants and/or bioassay.

i. Radioiodine

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

ii. Tritium

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

In the event a bioassay measurement indicates internally deposited radioactive material, additional bioassay measurements will be obtained. If initial bioassay measurements indicate an intake greater than 0.02 ALI, at least two additional bioassay 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 an evaluation of work practices during the iodination procedure.

13. RADIOACTIVE WASTE DISPOSAL PROCEDURES

a) General

Research with radioactive material generates radioactive waste in the form of solids, liquids, liquid scintillation vials, and animal carcasses. Investigators using radioactive material are responsible for minimizing the volume of waste generated and to consider use of alternate short half-life (<120 days) radionuclides when possible. Radioactive material in an EPA Hazardous Waste constitutes a mixed waste for which there are very expensive and limited national capacity for waste disposal. Steps should be taken to avoid generating mixed waste. If it is to be generated, it is mandatory that the RSO is notified in advance. 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 packaged properly, 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 provisions of the EVMS license.

b) Preparing Radioactive Waste for Disposal

Waste must be segregated by physical form, radionuclide, and half-life. Consideration of fire hazard from flammable liquid scintillation cocktail must be taken into account when storing these wastes for disposal. The waste storage area is a "Restricted Area" which means it must be kept secure at all times.

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 attached form RSO-10a "Radioactive Waste Drum Contents" with the date and activity in units of μCi or mCi .

DO NOT MIX RADIONUCLIDES IN ONE WASTE CONTAINER

ii. Liquid Waste

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

DO NOT MIX HAZARDOUS CHEMICAL WASTE WITH RADIOACTIVE WASTE

Clearly identify the bottle containing radioactive material by placing a piece of radiation warning tape on the side of the bottle. When the container is nearly full, prepare an RSO-10 indicating the radionuclide, activity (total μCi 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 cocktail for beta counting or an empty vial for gamma counting and count the sample. Convert the output in counts per minute (CPM) to disintegrations per minute (DPM), using the efficiency determined for the counter, then to units of μCi or mCi .

Convert CPM to units of activity and 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/ μ Ci

iii. Liquid Scintillation Vials

Place liquid scintillation vials containing cocktail in their shipping flat. When the flats are ready for disposal, estimate the total activity (μ Ci) and mark it on the side of the flat. Activity is estimated by counting 5 to 10 vials and estimating 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 μ Ci/g of ^3H and ^{14}C in medium used for liquid scintillation counting may be disposed as if it 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 (μ Ci or mCi), and frozen awaiting pick-up by Radiation Safety. Activity is determined by using the activity injected into the animal if there is negligible loss through excreta, or the difference between activity injected and activity excreted (solid or liquid waste). For carcasses containing ^3H or ^{14}C also include the weight of the animal. Animal tissue containing less than 0.05 μ Ci/g of ^3H and ^{14}C , when averaged over the weight of the whole animal, may be disposed as if it were not radioactive.

Example:

- A 250 gram carcass containing 12.5 μ Ci of ^{14}C would have an average concentration 0.05 μ 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 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. This information is necessary when completing the semi-annual inventory of radionuclides, on the RSO-11 "Semi-Annual Inventory" form.

14. ANIMAL USE PROCEDURES

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

Posting and Labeling. The Authorized User is responsible to ensure that cages are properly labeled and that rooms are properly posted.

- i. Cages 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 must have a radioactive material sign on the door if they contain more than ten times the value for the nuclide in use as listed in 12VAC5-481-3700.

b) Containment

Authorized Users must insure containment of radioactive waste by the use of under pads, excreta collection, etc., as appropriate. The Authorized User is responsible for ensuring that radioactive waste is disposed of properly and the disposal is recorded. Contact the Radiation Safety Office for assistance on carcass disposal.

c) Waste Disposal

- i. Litter, bedding, under pads, and carcasses containing radioactivity must be disposed as radioactive waste, unless excepted by regulation. Radiation Safety will provide a container marked with a radiation marking for solid waste. Waste should be placed in the container and the RSO-10a, "Radioactive Waste Drum Contents," completed indicating the date, radionuclide and activity disposed.
- 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, then labeled with radiation tape or tag identifying the radionuclide, activity, and investigator. Place the carcasses in a freezer 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 cages are cleaned, the Authorized User will conduct a survey in the room to assess potential contamination. The room will not be released for general use until Radiation Safety has reviewed the survey data.
- vi. Special instructions for caretakers must be written and posted on or near the animal cages. Investigators should provide special instructions in case of death or illness in the animals.

- 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 if radiation dosimeters are needed by animal care personnel, if the animal quarters should be a Restricted Area and if any other precautions which 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. For some types of radioactivity, specifically low-energy beta emitters, radiation dosimeters are not used.
 - Always wear disposable gloves and 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. In the event of personal contamination, immediately notify the Radiation Safety Officer.
- ii. Routine Operations
 - Feeding and watering may be carried out as with other animals, unless otherwise specified.
 - Absorbant 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.
 - Cages and room must be checked by the Authorized User prior to 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 collection by Radiation Safety personnel.

15. INVENTORY CONTROL FOR RADIOACTIVE MATERIALS

a) General

EVMS is licensed by the Commonwealth of Virginia to use specific radionuclides and may possess quantities designated in the respective license. Each Authorized User at EVMS is permitted to possess and use specific radionuclides in quantities designated in their permit. To ensure that neither EVMS nor Authorized User limits are exceeded, the Radiation Safety Office uses the web-based BioRAFT 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 BioRAFT, 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's 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 use, transfer and disposal for that particular material. Radiation Safety enters the quantity received in the database inventory system.

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. Each Authorized User reports their on hand inventory by radionuclide, form and activity using an RSO-11 "Semi-Annual Radioactive Materials Inventory," provided by the Radiation Safety Office. The inventory is a list of each radionuclide and chemical form held as either stock, labeled products or as waste.

f) Termination Inventory

Authorized Users are required to report their inventory to Radiation Safety on an RSO-9 at least 30 days prior to termination to allow adequate time for transfer or disposal 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 BioRAFT platform. To initiate the request, login to <https://evms.bioraft.com/> and select the “Rad Request” page under your laboratory profile. Once on page, you will need to submit the following information:
 - Company
 - Product Code
 - Compound - chemical form (e.g., dATP)
 - Active Isotope - (e.g., ¹⁴C)
 - mCi Requested (e.g., 20 mCi or 50 µCi)
 - Quantity
 - Grant or Department code, using the object code “**007328**” to indicate radioactive material, which shall be added in the Special Instructions section
- ii. The Authorized or Qualified User must complete requests at least five business days in advance.
- iii. Radiation Safety Office will verify that *the* Authorized User may receive the requisitioned material, and then enter the requisition in *OneSource Procurement*. Price changes, delays or other concerns will be discussed with the individual requesting the material.
- iv. The requisition must be approved in *OneSource Procurement* by your approving authority after Radiation Safety enters the order.
- v. Radioactive materials must be shipped to:

Radiation Safety Office
Eastern Virginia Medical School
700 West Olney Road Lewis Hall Room 2142
Norfolk VA 23507
- vi. The above procedures may be modified by the RSO, in case of emergency or immediate need for short-lived radioactive materials, provided that all administrative, legal, record-keeping, receiving and survey requirements are met.

If you need assistance
with your order, please
contact the RSO!

b) Receiving Procedures

- i. Radioactive material is received at the Radiation Safety Office, Lewis Hall Room 2142, between the hours of 9:00 am and 3:30 pm, Tuesday through Friday.
- ii. The person receiving the package verifies that it's addressed to EVMS and that there is no visual damage to the package, before signing the delivery service receipt. 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 be used to document receipt of all packages containing radioactive material. The RSO-8 contains information about 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 exterior surfaces of the box. Count the wipes and record the results on RSO-8.
 - 3) Remove the packing list and open the package then 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 if feasible or discard 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

Transfer of radioactive materials, either within EVMS or to individuals or institutions outside of EVMS must be approved by the Radiation Safety Officer prior to the occurrence.

- i. Transfer within EVMS. Transfer of radioactive material, regardless of quantity, can occur only between Authorized Users who are authorized for that quantity of that radionuclide and only with prior RSO approval. After transfer, the total quantity cannot exceed the users permit limits. Complete the transfer section of the RSO-9 "Radioactive Material Use and Transfer" form and contact the Radiation Safety Office for approval. Packaging requirements will be managed by the RSO.
- ii. Transfer outside of EVMS. All transfer of radioactive material to individuals or institutions outside of EVMS will be performed by the RSO. Federal and state regulations require license verifications, special packaging and labeling, and record-keeping which must be managed by the RSO. Department of Transportation (DOT) regulations require specific shipping procedures be used 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. Transport of radioactive materials is divided into several classes. In all cases, materials producing external radiation shall be shielded to keep radiation levels as low as reasonably achievable (ALARA).
 - For transport BETWEEN ROOMS in the same building, precautions shall be taken to minimize the possibility of spills or releases, but no special packaging is required as long as an Authorized or Qualified User accompanies the material.
 - For Transport BETWEEN FLOORS in the same building, cargo elevators shall be used.
 - For foot transport BETWEEN BUILDINGS, radioactive materials shall be shielded as above and packed to minimize the possibility of spills or releases in the event the package is dropped. Utilizing secondary containment and cart transport minimizes the potential for radioactive material spills. Special care shall be exercised when crossing streets.
 - For VEHICULAR TRANSPORT, regardless of distance, radioactive materials must be shielded as above and packaged according to Department of Transportation specifications. Contact the Radiation Safety Officer for more information as needed.

18. HUMAN USE OF RADIOACTIVE MATERIALS

The Eastern Virginia Medical School 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. Assuring the personnel are aware of and follow proper procedures in the use of the equipment and the radiation hazards associated with its operation.
- iii. Notifying the Radiation Safety Office when there is any change in the setup, i.e., new equipment installed, changes in shielding, change in radiation output, or change in usage of the unit.
- 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. Wearing appropriate monitoring devices. Always wear an assigned radiation dosimeter when operating the unit. Whenever protective lead aprons are worn, the dosimeter shall be worn outside the apron at the neckline. In addition, wrist or rings dosimeters shall be worn if the unprotected hands and forearms must come within close proximity of the beam.
- ii. Keeping all exposures ALARA. An operator 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.
- iii. Clearing the area of non-essential personnel.
- iv. Observing any restrictions on use of the unit.
- v. 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.
- vi. Notifying the supervisor and the Radiation Safety Office immediately of any accidental exposure to radiation.
- vii. Keeping the unit disconnected or locked when not in actual use.
- viii. 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 authorization from the Radiation Safety Committee, before they acquire the equipment.

Environmental Health and Safety has an ortho-voltage x-ray machine available for research studies. Contact Radiation Safety to schedule time and exposures. The fee for service schedule is posted and is available on request.

b) Policies

- i. All operators of radiation producing machines and personnel in the immediate area shall be required to wear a radiation dosimeter.
- ii. All areas in which radiation-producing machines are operated shall be posted with the characteristic radiation tre-foil warning sign.
- iii. The structural shielding requirements of any new installation or an existing unit in which changes are contemplated shall be discussed with and approved in advance by the Radiation Safety Officer.
- iv. A radiation survey shall be made of new installations and existing units after every change that might increase the radiation hazard, i.e., replacement of x-ray tubes, changes to installed filtration, etc.
- v. Unless measurements indicate that they are not needed, protective aprons shall be worn by the operator, and by all other persons within the room or area who are frequently exposed to radiation.
- 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 subject during the exposure and shall wear a protective apron or step behind an adequate barrier.
- ii. The operator shall not take more than 5,000 mA-seconds of exposures during any one-week. Rotation of operators or the use of portable shields is recommended for greater workloads.
- iii. The hand of the fluoroscopist, either with or without gloves, shall never be placed in the useful beam unless the beam is attenuated by the subject.
- iv. No person shall be regularly employed to hold animals during exposure. Restraint apparatus shall be designed to protect animal welfare and obtain desired images.
- v. If 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 output of the unit, then this restriction shall be rigidly adhered to.

- vi. Shutter mechanisms and interlocking devices shall not be tampered with and shall be inspected frequently in order to assure proper operation.
- vii. At yearly intervals, lead aprons, gloves and personal protective equipment shall be inspected for deterioration and the results recorded.
- viii. Equipment found compromised will be replaced prior to using the machine.
- ix. A manually reset cumulative timing device shall be used which either would indicate elapsed time or turn off the apparatus when the total exposure reaches a certain 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 possible situations 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 corrective actions taken to prevent a recurrence. The Radiation Safety Office will determine if a report to external agencies is necessary and, if so, will prepare and submit the report. Radiation Safety will also assist with personnel decontamination and determine the need for additional decontamination methods and bioassay.

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. Contain the spill by covering it with absorbent material (paper towels, disposable pads, etc.). Don 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 by other technique, i.e. wipe test for a spill containing ^3H . Survey adjacent areas, such as the hallway and door entry, for 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 to remain nearby for monitoring and to prevent the spread of contamination.

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

NOTE: If the spill involves a dust, mist, organic vapors or gases, shut down the ventilation, if possible, unless the ventilation 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 the spill is on clothing, remove and discard clothing immediately. Use an emergency shower if necessary.
- 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 event of minor fire such as a fire in a beaker or on the bench, attempt to put it out by smothering or use of 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 spread of contamination.
- iv. Monitor personnel involved in firefighting for contamination and decontaminate as needed by removing contaminated clothing and flushing contaminated skin with lukewarm water, then 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 approved by the RSO.
- 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 in use 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 to establish a control point to monitor personnel leaving the area after controlling the emergency. Assist with contamination surveys of emergency personnel and equipment.
- v. The RSO will supervise decontamination of the area. Based 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 there is radioactive contamination on the skin, flush thoroughly with water. If the contamination is on clothing, discard outer clothing at once. Use emergency shower if necessary. 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 the nature of injuries, if any; identify the radionuclides and activity involved and 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 possible 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. Permit no person involved in a radiation injury to return to work or leave the premises without 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 be in contact with 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 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 are primarily concerned with reducing the likelihood of inhalation or ingestion.

As a rule, except for decontamination of hands, or except in cases of emergency as agreed upon by the Radiation Safety Officer, all mild decontaminating procedures described below should be carried out under supervision of the Radiation Safety Officer. 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 and in such a way as not to abrade the skin;
- The skin should be washed for a few minutes at a time, then dried and monitored.

Washing could be repeated if necessary (as indicated by monitoring) providing there is no indication of skin damage.

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

Use of organic solvents or of acid or alkaline solutions should be avoided.

Special attention should be paid to proper decontamination of creases, folds, hair and of parts of the hands such as fingernails, inter-finger space and the outer edges of the hands.

Care should be taken to avoid spreading the contamination to uncontaminated parts of the body 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, with a proper masking of the adjacent non-contaminated areas of the skin. A non-contaminated open wound should be protected.

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

When decontaminating the face, special care should be taken not to contaminate the eyes, nasal passages or lips.

Decontamination of the eyes should be undertaken immediately. Not only the radioactive isotope is to be considered, but also the chemical nature of the contaminant and eventual complications due to foreign bodies and mechanical or chemical irritants. Additional irritation of the eyes by decontamination procedures should be avoided. Immediate irrigation of the eyes with a copious amount of water or with appropriate medically approved solutions is recommended. These solutions and a suitable vessel for eye washing should be provided for first-aid. After initial decontamination (irrigation) of the eyes, the patient should be referred to a medical specialist for further treatment.

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 normal working hours, it should be immediately reported to the Radiation Safety Officer or Public Safety.

Internal contamination is essentially a medical problem, parallel in some ways to the absorption of chemical toxins. Special procedures should, therefore, be conducted under medical supervision.

Aims of the corrective procedures are: (a) to eliminate as much of the internally introduced contaminant still 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 that the contaminated person or another non-medical person take immediate action (in the first seconds or minutes) for instance, to promote the mechanical elimination of the contaminant by vomiting or expectoration.

In case of contaminated small open wounds, cuts, punctures, or other injuries, the wound should be immediately washed and 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 of radioactive materials, contact EVMS 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 scene of the incident to assist and to control entry and exit from the area. No one is to be permitted to leave unless a trained person has monitored them for radioactive contamination. Do not eat, drink, or smoke in the incident area, or use food or drink which may have been in contact with radioactive material. 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
 - Associate Radiation Safety Officer via Public Safety: 446-5199
 - Chairman, Radiation Safety Committee via Public Safety: 446-5199

- Faculty member 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 reaching the scene of an incident, Police and Public Safety Officers should help determine if injured persons need emergency care, and take steps to provide it.
 - vi. When a transportation incident involves radioactive material, do not move vehicles, shipping container, or wreckage, except to rescue 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 edge of the pathway to minimize dispersal of the spilled material.

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 EVMS Marketing & Communications. No other person is authorized to speak on behalf of EVMS. Contact EVMS Marketing & Communications at 757-446-7070.

l) Supplement to Emergency Procedures for Radiation Safety Personnel

i. Procedures on 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 individual reporting the accident.
- Dispatch a person from the Radiation Safety Office or a member of the Radiation Safety Committee to the location of the accident as quickly as possible.
- If the accident involves possible radioactive contamination of an injured individual, arrange for a person from the Radiation Safety Office or a member of the Radiation Safety Committee to go immediately to the medical facility where the victim has been taken.
- If the accident appears to be of such magnitude that it needs to be reported either to the NRC or the Virginia Department of Health, 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 the report.
- 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 a period of 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 spread of contamination. Save all items of contaminated clothing, personal effects, etc.
- ❑ Obtain complete names, birth dates, social security numbers, and addresses of all individuals involved in the accident. Keep them at the scene until all necessary information has been obtained.
- ❑ Start survey operations to establish magnitude of possible exposure to the individuals involved.
- ❑ Start survey of contamination levels and record 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 names of all individuals involved in the accident.
- ❑ Check radiation levels in areas accessible to personnel to avoid 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 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 will be received from an intake of radioactive material by an individual 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 designed to detect radiation. It refers to the total number of events registered by the detector in one minute.

Curie (Ci): A unit of activity. One curie = 3.7×10^{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): Applies to external whole body exposure; dose equivalent at 1 cm (1000 mg/cm^2) depth.

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

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 of the body organs or tissues that are irradiated.

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 keV = 10^6 or MeV = 10^{12} . One eV = 1.6×10^{-19} erg.

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

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

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

Gray (Gy): The SI unit for absorbed dose that is equal to 1 Joule /kg.

Half-Life, Biological (T_B): 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_E): The time required for a radioactive element in the body to be reduced by one half as a result of radioactive decay and biological elimination.

Half-Life, Radioactive (T_P): 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 atoms or molecule acquires a positive or negative charge.

Irradiation: Exposure to radiation.

Isotope: Nuclides having 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 nuclear constitution is specified by the number of protons (Z), number of neutrons and energy content.

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 through materials, such as alpha, beta and gamma radiation.

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

Shallow Dose Equivalent (H_s): External exposure to the skin or extremity; dose equivalent at 0.007 cm (7 mg/cm^2) 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 sources of radiation under specific conditions.

Total Effective Dose Equivalent (TEDE): The sum of deep dose equivalent and the committed dose 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 irradiation of that organ or tissue 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 basic components, which on the basis of an evaluation could create a substantial safety hazard involving radioactive material. A substantial safety hazard means loss of a safety function to the extent that there is a major reduction in the degree of protection to public health and safety. For EVMS there is a potential for moderate personal exposure to licensed material 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 ≥ 0.5 rem to an individual in an unrestricted area in a year or less.
 - ii. Potential release of 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, 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 following receipt of information from the Chairman, 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, 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, 12VAC5-481-1530.

Appendix D - Forms

Most forms are available on the EVMS MyPortal website:

https://myportal.evms.edu/research/safety/environmental_health_and_safety/

- RSO-1 Application for User Status
- RSO-2 Application for Possession and Use
- RSO-3 AU Renewal Application
- RSO-4 Application for Radiation Device
- RSO-5 Periodic Contamination Survey Exemption
- RSO-6 AU Termination Notice
- RSO-8 Radioactive Material Order and Receipt
- RSO-9 Radioactive Material Use and Transfer
- RSO-10 Request for Radioactive Waste Collection
- RSO-10a Radioactive Waste Drum Contents
- RSO-11 Semi-Annual Inventory
- RSO-12 Survey Instrument Calibration
- RSO-13 Radiation Survey Form
- RSO-16 Request for Dosimetry
- RSO-17 Request for Dosimetry-Spare Badge
- RSO-18 Prenatal Instructions
- RSO-18a Declaration of Pregnancy
- RSO-19 Lost Dosimeter
- RSO-21 Request for Personnel Dosimetry
- RSO-21a Exposure History
- RSO-22 Iodinization Safety Checklist

If the form you need isn't listed, *please* contact Environmental Health and Safety for assistance!