1. **Purpose:** The following procedure describes good lab practices when handling radioactive materials while following the ALARA principles.

2. **Scope:** Radiation Workers (RWs), Authorized Users (AUs), and Permitted Individuals (PIs) should use this procedure to develop permit-specific procedures for safely handling RAM. When creating new procedures, refer to the Radiation Safety Manual (RSM) for additional information and requirements.

3. **Definitions:**

   3.1 Bremsstrahlung Radiation – produced when high-energy, charged particles are abruptly stopped or change direction. This phenomenon, also known as "Braking Radiation," is often seen with beta particles and will produce x-rays.

   3.2 Permitted Individual (PI) – the individual response for overseeing all uses of RAM under their RAM permit.

4. **Procedure Details:**

   4.1 Protective Clothing

   4.1.1 Disposable gloves shall be worn when handling radioactive materials in unsealed form and when handling any item in the radiation work area. Contaminated gloves shall be removed and disposed of in a radioactive waste container.

   4.1.2 Lab coats or similar protective clothing shall be worn when handling radioactive material in unsealed form. Lab coats worn in potentially contaminated areas shall not be worn in non-radioactive areas, unless surveyed and found to be not contaminated.

   4.1.3 When actively working with RAM, full-length pants or equivalent must always be worn. The area of the skin between the pants and shoes should not be exposed.

   4.1.4 Closed-toe shoes shall be worn when handling radioactive material in unsealed form.

   4.1.5 Wear safety glasses or goggles when handling unsealed RAM or entering a laboratory.

   4.1.6 After each procedure or before leaving the area, monitor hands, shoes, and clothing for contamination in a low-background area.

   4.1.7 Always refer to the Personal Protective Equipment section of the EHS webpage for more information.

4.2 Shields and Protective Devices

4.2.1 Lead or similar high-density shielding is required for routine handling of gamma emitters.

4.2.2 Shielded syringes should be used when handling doses of gamma or high-energy beta emitters.

4.2.3 Plastic or other low-density shielding should be used when handling high-energy beta emitters such as P-32.

4.2.4 Shielding may be needed for radioactive waste storage as well as for the work area.

4.3 Labeling of items and equipment

4.3.1 Small items, such as pipettes, syringes, or pens, should be individually labeled with a radioactive materials sticker if potentially contaminated. Alternatively, the items should be confined to a well-defined and labeled area which indicates that any items in that area are contaminated or have the potential to be contaminated.

4.3.2 Equipment such as centrifuges, refrigerators/freezers, fume hoods, etc., should be labeled when the use of these items could lead to internal contamination. Labeling, along with appropriate training of all personnel, will preclude the spreading of contamination by multiple users of this equipment.

4.3.3 Any vial containing radioactive material must also be labeled with the radionuclide, activity, assay date, and any other important information. Refer to the Radiation Safety Manual for exceptions from labeling.

4.4 Fume Hoods and Glove Boxes

4.4.1 Fume hoods or other forms of secondary containment must be used when working with RAM that is bound or incorporated into a chemical or physical form which may become airborne or volatile. Examples include dusts, iodine, compounds with a high vapor pressure, compounds which sublime, or any actions which may cause atomization.

4.4.2 Experiments with commonly authorized radionuclides that may pose an airborne risk include I-125 or I-131 sodium iodide, S-35 methionine, H-3 as tritiated water, and sometimes C-14 labeled organic solvents.

4.5 Security

4.5.1 Secure all RAM when it is not under the constant surveillance or immediate control of the user(s).

4.5.2 Store and use RAM only in approved areas.

4.5.3 Limit access of radiation areas to approved Radiation Workers. Ancillary Workers may access radiation areas if approved to do so and with appropriate ancillary training.

4.5.4 Use storage areas that can be locked to prevent access to RAM.

4.5.5 Remain within "line of sight" whenever RAM is in use.

4.6 Keep accurate records of RAM receipt and usage. Note any transfers in or out, and keep records of waste disposal, including non-radioactive chemical constituents.

4.6.1 If RAM is transferred across campus, it must be walked. RAM can only be transported in a vehicle by the Radiation Safety Staff (RSS).

4.6.2 When walking with RAM, a cart may be beneficial to increase distance from the source.

4.6.3 Use secondary containment, especially for liquids.

4.6.4 If transporting unsealed ram, ensure that the vial is contamination-free.

4.6.5 Always use appropriate shielding to minimize dose rates.

4.7 Make sure the required training for all personnel is up to date and provide function-specific or lab-specific training as needed.

4.8 Monitoring of the area must be conducted after each use of unsealed RAM and in the case of spills and decontamination. Hands, shoes, floor, work area, etc. must be monitored after each use of RAM. Documented surveys must be done at the specified intervals designated in the Radiation Safety Manual. Both meter surveys and swipe surveys should be performed; swipes are valuable in assessing removable contamination.

4.9 In addition to the previous items, recommended topics to include in the procedure and implement as lab practices include:

4.9.1 Do not eat, drink, smoke, or apply cosmetics in any area where RAM is stored or used.

4.9.2 Do not store food, drink, or personal items in any area where RAM is used or stored.

4.9.3 Wear personnel monitoring devices, if required, in areas where RAM is used or stored.

4.9.4 Dispose of radioactive waste only in designated, labeled, and properly shielded containers.

4.9.5 Never pipette by mouth.

4.9.6 Store radioactive solutions in clearly labeled containers.

4.9.7 Safely handle sealed sources.

4.10 As part of the RAM permit application process, the PI must submit a procedure describing how RAM will be used and stored along with additional radiation safety precautions. Below are common radionuclides used at the University of Missouri along with useful safety recommendations to incorporate into the required procedures.

4.10.1 H-3 (Tritium)

4.10.1.1 Tritium cannot be detected with a Geiger-Mueller (GM) detector, making it difficult to monitor for contamination during use. The regular use of wipe testing with liquid scintillation counting (LSC) is the only way to ensure the area is not contaminated.

4.10.1.2 Internal exposure is the main pathway of concern. Therefore, caution should be used to prevent absorption, ingestion, inhalation, or injection. If an internal exposure is suspected, contact the Radiation Safety Staff (RSS). Urine bioassays may be necessary.

4.10.1.3 The energy of the beta particle emitted from tritium is low enough that shielding is typically not necessary.

4.10.1.4 If tritiated water is used or tritium may be heated, use a fume hood or glove box to minimize internal exposure.

4.10.1.5 Tritium has a relatively long half-life of 12 years and should be segregated from other radionuclides to minimize waste volume.

4.10.1.6 Because tritium can often be in the form of tritiated water, it will move like water. If tritium is stored in a freezer for a long period, there is a chance that any ice that builds up in the freezer could become contaminated with H-3. Thus, any frosted freezers should be treated with caution, especially if they begin to thaw.

4.10.2 Carbon-14

4.10.2.1 C-14 can be treated similarly to tritium as far as radiation safety precautions.

4.10.2.2 C-14 cannot be easily detected with a GM. Therefore, regular use of wipe testing with an LSC is the main way to ensure the area is not contaminated.

4.10.2.3 Since the energy of the C-14 beta particle is relatively low, internal exposure is the main pathway of concern. Use caution to prevent internal exposure and contact the RSS if exposure is suspected.

4.10.2.4 Low-density materials such as plastic (Plexiglass), aluminum, or wood can be used to shield C-14. However, the low energy of the beta particle should not produce a high dose rate and therefore may not require any shielding.

4.10.3 Phosphorus-32

4.10.3.1 P-32 can easily be detected by a GM. It is a good practice to have a GM set up near the workstation whenever P-32 is being used so that the Radiation Worker can easily survey hands, feet, and the area.

4.10.3.2 Swipe surveys with an LSC also have a high efficiency for detecting P-32 and are a useful means of identifying contamination.

4.10.3.3 P-32 is a high energy (1.7 MeV) beta emitter, so the main exposure pathway of concern is external. Appropriate low-density shielding such as plastic/Plexiglass (preferred), aluminum, or wood should be used whenever working with P-32. Avoid using higher density materials such as lead; interaction of the high energy beta particle with the high-density material will create Bremsstrahlung radiation.

4.10.3.4 Dosimeters may be necessary depending on the activity used during experiments. This will be assessed by the RSS during RAM permit applications.

4.10.4 Radioiodines (including I-125 and I-131)

4.10.4.1 Radioisotopes of iodine (radioiodines) can be volatile if in an unbound form such as sodium iodide. Therefore, the use of volatile radioiodine should be done in a fume hood when possible.

4.10.4.2 If radioiodine is bound to a ligand, such as I-125 radioimmunoassay (RAI) kits, then the iodine can be handled on a benchtop since it will not be volatile.

4.10.4.3 Handling unsealed radioiodines may require in-vivo thyroid bioassays to measure the amount of uptake to the thyroid, especially if a suspected intake occurs. Users of volatile radioiodines should not use the material if they cannot commit to having a bioassay completed in an appropriate timeframe.

4.10.4.4 When cleaning up radioiodine contamination, do not use bleach or acidic compounds because this can re-volatilize any iodine contamination that may be bound.

4.10.4.5 External exposure may also be of concern depending on the radioiodine used. I-125 emits low energy gamma and x-rays and typically does not need shielding. I-131 emits both beta particles and gamma rays, so graduated shielding such as a layer of plexiglass followed by lead should be sufficient; alternatively, thick lead may be sufficient to shield any Bremsstrahlung generated by the beta particles. I-123 emits gamma rays and can be shielded with lead. I-124 is a positron emitter and can also be shielded with lead.

5. References:

5.1 NUREG 1556, Volume 7, Revision 1, Appendix I

5.2 NUREG 1556, Volume 7, Revision 1, Appendix M

5.3 NUREG 1556, Volume 11, Revision 1, Appendix H

5.4 NUREG 1556, Volume 11, Revision 1, Appendix L

5.5 NUREG 1556, Volume 9, Revision 3, Appendix R

5.6 10 CFR 20.1101

5.7 10 CFR 20.1201

5.8 10 CFR 30.33(a)(2)

6. Revisions

6.1 Rev 01 – 2024-1-5 – New SOP. Supersedes old Radiation Safety Manual page titled “Good lab practices when handling RAM in a lab.”