



**Harry S. Truman Memorial
Veterans' Hospital
Columbia, Missouri**

Research Service

Radiation Safety Policies & Procedures Manual

FEBRUARY 2015



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INTRODUCTION

The use of radioactive material within the confines of the VA Research Service cover a wide range of applications that include basic research and development (R&D), diagnostic imaging, therapeutic radiopharmaceutical research, and a research irradiator. Policies and procedures have been developed to provide a safe work environment while allowing research workers the flexibility to perform their individual experimentation and maintain compliance with regulatory organizations.

Control and security of hazardous agents in VA research laboratories is outlined in VHA Handbook 1200.06. These regulations provide a starting template for the policies and procedures used when hazardous biological, chemical and radiological materials are in use. Security of these hazardous agents and the research laboratories is required at all times, 24 hours a day. Research workers that will have unescorted access to the research restricted areas must have a valid VA identification card and be provided with instruction in the safe use of these materials. **All research personnel working with or in the vicinity of radioactive material are required to read and understand these basic policies and procedures as part of the radiation safety orientation process before unescorted access will be granted by the Research Office.** This requirement includes research investigators, laboratory technicians (both full and part-time) and students with WOC appointments (with-out compensation). Ancillary personnel such as housekeeping, facilities management, and police are provided with separate instruction for entering the research areas.

Many VA researchers are also affiliated with the University of Missouri (UMC) and are considered authorized users at one or both locations. The University of Missouri Environmental Health and Safety Office (EHS) publish a Radiation Safety Handbook for personnel involved with radioactive material under their U.S. Nuclear Regulatory Commission (NRC) broad scope license. The Radiation Safety Officers (RSO) of both facilities communicate to aid workers in purchasing and transferring radioactive materials from one facility to another. Questions about these procedures should be directed to the Radiation Safety Officer for clarification.

SECTION 1.0 REGULATION OF RADIOACTIVE MATERIAL

1.1 Nuclear Regulatory Commission License

The U.S. Nuclear Regulatory Commission (NRC) issued the Veterans Health Administration (VHA) a Master Materials License (NRC License No. 03-23853-01VA) effective March 17, 2003. Under the master materials license, the VA is authorized to issue permits for the use of radioactive materials to each facility in the same manner as NRC. The latest permit for the Harry S. Truman Memorial Veterans' Hospital can be obtained from the RSO. The broad scope MML permit is written to give the licensee the greatest amount of flexibility, so that research and development can proceed in a safe manner with the least amount of external regulatory involvement.

1.2 The Radiation Safety Committee

The Radiation Safety Committee (RSC) is appointed by the Hospital Director to oversee the use of all ionizing radiation within the hospital. The RSC is charged with monitoring the hospital radiation safety program, which includes authorizing new research investigators, research radiation workers, personnel exposure monitoring and enforcement of hospital policy. The committee makes recommendations to management concerning corrective actions or other suggestions to strengthen the radiation safety program. The current committee membership and function information can be found on the hospital web page under boards and committees (Radiation Safety Committee, B&C 589A4-13).

1.3 The Radiation Safety Officer

The Radiation Safety Officer (RSO) manages the radiation safety program on a daily basis and provides instruction and training to staff working with radioactive material. The RSO must ensure that radioactive materials are being used in a safe manner and in compliance with all federal regulations and the VHA Materials Permit. The RSO has the authority to immediately halt any activity judged to be a threat to health and safety or a violation of the conditions of the hospital's Permit. The RSO has the authority to inspect any area of the hospital where sources of ionizing radiation are in use or stored.

1.4 The Radiation Safety Office and Laboratory Facilities

The Radiation Safety Office is located in room B049 in the basement of the hospital and staffed by 2.0 FTE Safety & Occupational Health Specialists. Office hours are routinely 7:30 A.M. to 4:00 P.M. Monday through Friday. The Radiation Safety Office is affiliated with the Hospital Safety Office under the supervision of the Facilities Management Director.

Radiation Safety Officer (RSO):

Richard E. Poelling, Safety & Occupational Health Specialist
Office Room Number: B049
Office Phone Number: (573) 814-6000 Extension 52590
Pager Number: 5464
E-mail: Richard.Poelling@va.gov

After-hours Emergency: Call operator or police to contact RSO

Health Physics Lab and Radioactive Package Receipt:

Mary Aldrich-Sarafianos, Health Physicist
Health Physics Lab: B050
Phone extension: 52594
Cell Phone: 573-529-2385
E-mail: Mary.Aldrich-Sarafianos@va.gov

1.5 Research Authorized Users of Radioactive Material

To be an authorized user, an application to use specified radioactive material for investigative research must be approved by the Radiation Safety Committee (RSC). Authorized users of uncontained radioactive materials (greater than 10 CFR 20 Appendix C quantities) must meet the criteria in 10 CFR 33.15(b)(1) and (2):

- A college degree at the bachelor level, or equivalent training and experience, in the physical or biological sciences or in engineering; and
- At least 40 hours of training and experience in the safe handling of radioactive materials, (a) in the characteristics of ionizing radiation, (b) the units of radiation dose and quantities, (c) radiation detection instrumentation, and (d) biological hazards of exposure to radiation appropriate to the type and forms of byproduct material to be used are required. Of the 40 hours, 8 hours should be formal classroom hours covering the subjects listed in (a) through (d) above.

Applications to the RSC should be obtained from the Radiation Safety Officer. When the application is approved by the Radiation Safety Committee, a "Radioactive Materials Permit" will be issued to the authorized user indicating the individual radionuclides and the maximum possession limits. The permit will also indicate the approved laboratory space, required survey frequency and specific limitations or conditions that apply to the user.

RESEARCH SERVICE – RADIATION SAFETY MANUAL

Note: Approval by the Radiation Safety Committee, by itself, does not authorize research activity within the VA facility. Prior to conducting research studies, Research & Development committee approval is also required.

1.6 Radiation Workers

Radioactive materials can only be used in this hospital by a radiation worker under an approved authorized user. A radiation worker is allowed to handle radioactive material without being directly supervised by the authorized user or another radiation worker. Radiation workers possess the training and experience to independently work with radioactive material. To become an approved radiation worker, you must complete the "Radiation Workers Training and Experience" form, read the Research Radiation Safety Policies and Procedures Manual and complete a short open book test to demonstrate understanding and competency. A new radiation worker with limited educational knowledge or experience can be approved under the direct supervision of the authorized user or another experienced radiation worker within the group.

1.7 Ancillary Workers

An ancillary worker may have access to radioactive materials or radioactive work areas, but do not routinely handle radioactive materials except under the direct supervision of a Radiation Worker. The authorized user or designated radiation worker is responsible for providing instruction to the ancillary worker. This instruction will include control and security of radioactive materials.

1.8 Reporting Radiation Safety Concerns

Radiation workers may report radiation safety concerns to their supervisors (Authorized User), to the Radiation Safety Officer, to the National Health Physics Program, to the VA Inspector General, or to the Nuclear Regulatory Commission.

Local facility supervisors and/or Radiation Safety Officers are normally the first resource for radiation workers to use to voice radiation safety concerns. Other local resources include the Chair, Radiation Safety Committee, committee members, or senior management.

The VHA National Health Physics Program (NHPP) is an outside resource that staff may contact to communicate radiation safety concerns. The NHPP is under the aegis of the National Radiation Safety Committee and senior headquarters-level management who regulate and inspect the individual hospitals under the Master Material License. The NHPP has established procedures to evaluate, in confidence, worker radiation safety concerns and/or allegations. The NHPP point of contact is:

NHPP Director, at (501) 257-1571

NHPP Headquarters: 2200 Fort Roots Drive (115HP)
Building 101, Room 208E
North Little Rock, AR. 72114
Fax: (501) 257-1570

The VA Inspector General is another outside resource that staff may contact to communicate radiation safety concerns. The telephone number for the VA Inspector General's "Hotline" is (800) 233-3497.

The Nuclear Regulatory Commission is also an outside resource that staff may contact to communicate radiation safety concerns. Medical centers or facilities with a Nuclear Regulatory Commission license are required to post the NRC Form-3 with information about points of contact. As an example, one point of contact listed on the NRC form-3 is the NRC Safety Hotline at (800) 695-7403.

Reporting radiation safety concerns is considered a protected activity under title 10, Code of Federal Regulations Parts 19 and 30, the Civil Service Reform Act of 1978, and the Whistleblower Protection Act of 1989.

1.9 What is Your Responsibility?

For your own protection and the protection of your co-workers, you should know how radiation safety requirements relate to your work and should obey them. If you observe violations or have a safety concern, you are required to report them to the RSO. If you engage in deliberate misconduct that may cause a violation of the NRC requirements, or would have caused a violation if it had not been detected, or deliberately provide inaccurate or incomplete information to either the NRC or to your employer, you may be subject to enforcement action.

SECTION 2.0 – RADIATION TERMS AND DEFINITIONS

2.1 Types of Radiation

Radiation is energy in the form of waves or particles. X-rays and gamma rays are electromagnetic waves of radiation, as is visible light. Particulate radiation includes alpha and beta radiation. The energy associated with any radiation can be transferred to matter. This transfer of energy can remove electrons from the orbit of atoms leading to the formation of ions. The types of radiation capable of producing ions in matter are collectively referred to as "ionizing radiation."

2.2 Ionizing Radiation

Ionizing radiation is radiation which has enough energy to cause atoms to lose electrons and become ions. Alpha and beta particles, as well as gamma and x-rays, are all examples of ionizing radiation. Ultraviolet, infrared, and visible light are examples of non-ionizing radiation.

2.3 Alpha Particle

Alpha particles are composed of two protons and two neutrons. Alpha particles do not travel very far from their radioactive source. They cannot pass through a piece of paper, clothes, or even the layer of dead cells, which normally protects the skin. Because alpha particles cannot penetrate human skin they are not considered an "external exposure hazard" (this means that if the alpha particles stay outside the human body they cannot harm it). However, alpha particle sources located within the body may pose an "internal" health hazard if they are present in great enough quantities. The risk from indoor radon is due to inhaled alpha particle sources, which irradiate lung tissue.

2.4 Beta Particle

Beta particles are similar to electrons, except they come from the atomic nucleus and are not bound to any atom. Beta particles cannot travel very far from their radioactive source. For example, they can travel only about one centimeter or less in water or human tissue, and they may travel a few meters in air. Their ability to penetrate material is dependent upon their energy. The table below provides information on the typical beta emitters used in many research laboratories. Compare the maximum energy of each nuclide with the range in air, water/tissue, and plastic.

Since beta particles are charged particles, they have a definite, predictable range beyond which they will not travel. In principle, then, if a thickness of shielding greater than or equal to their range is

placed in their path, 100% of the betas will be stopped. In practice, the betas will be stopped, but they produce bremsstrahlung radiation as they slow down and come to rest. Thus the relatively non-penetrating beta rays "turn into" a penetrating photon source. The intensity of the bremsstrahlung radiation is proportional to the number of betas, their energy and the atomic number, Z, of the absorber (shield). Common beta shields use plastic (low Z due to the high carbon and hydrogen content) or acrylic sheets that are 3/8 inch thick to minimize the production of bremsstrahlung radiation. If Bremsstrahlung x-rays are detected outside the Plexiglas, apply 3 to 6 mm of lead (Pb) shielding.

Characteristics of Common Research Beta Emitters

Nuclide	Maximum Energy (keV)	Physical Half-life (T1/2)	Beta Range		
			Air	Water/Tissue	Plastic
³ H	18.6	12.3 years	0.6 cm	0.006 mm	NA
¹⁴ C	156	5730 years	24 cm	0.28 mm	0.25 mm
³² P	1710	14.3 days	610 cm	0.76 cm	0.97 mm
³³ P	248.5	25.3 days	50 cm	0.06 cm	0.05 cm
³⁵ S	167.5	87.4 days	26 cm	0.32 mm	0.25 mm
⁹⁰ Y	2280	64.1 hours	900 cm	11 mm	

2.5 Gamma Rays

Gamma rays are an example of electromagnetic radiation, as is visible light. Gamma rays originate from the nucleus of an atom. They are capable of traveling long distances through air and most other materials. Gamma rays require more "shielding" material, such as lead or steel, to reduce their numbers than is required for alpha and beta particles.

Gamma rays emitted from radionuclides cover a wider range of energies than either beta rays or alpha particles. The lowest known gamma ray energy is 0.008 MeV (from ¹⁶⁹Er) and the highest is 7.11 MeV (from ¹⁶N). The most common gamma ray energies in the occupational environment range from about 0.15 to 1.5 MeV. The table below lists some radionuclides utilized at this hospital, which emit gamma radiation and their specific exposure rate constant. The specific exposure rate constant gives the exposure rate (R/hr) at a specified unit distance from a specified activity of a photon emitting radionuclide. The quantity is useful for estimating the external hazard from a source.

Radionuclide	Gamma Energy (% Abundance)	Physical Half-life (T1/2)	Gamma Constant R/hr at 1 cm from an unshielded 1 mCi point source	Gamma Ray Shielding (Half-Value-Layer of Lead)
^{99m} Tc	141 keV (89%)	6.0 hours	0.77	< 1 mm
¹¹¹ In	245 keV (94%) 171 keV (90%) 23 keV (69%)	2.8 days	3.3	< 1 mm
¹²⁵ I	35.5 keV (7%)	60.14 days	2.7	0.02 mm
¹³¹ I	364 keV (81%)	8.04 days	2.8	3 mm

2.6 X-rays

X-rays are defined as penetrating electromagnetic radiation whose wavelength is shorter than that of visible light; usually produced by bombarding a metallic target with fast electrons in a high vacuum; in nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and

those originating in the extra nuclear part of the atom as x rays; sometimes called Roentgen rays, after their discoverer, W.C. Roentgen.

2.7 Exposure

Radiation exposure is a measure of the amount of ionization produced by x-rays or gamma rays as they travel through air. The unit of radiation exposure (in air) is the roentgen (R), named for Wilhelm Roentgen, the German scientist who in 1895 discovered x-rays. The roentgen (R) or more commonly its submultiple, the milliroentgen (mR) is used as a value for most survey meter readings. Adding a time factor permits a total exposure determination. Most survey meters are calibrated in mR/hr. (pronounced: milliroentgen per hour)

2.8 Radiation Dose

The effect of radiation on any material is determined by the "dose" of radiation that material receives. Radiation dose is simply the quantity of radiation energy deposited in a material. There are several terms used in radiation protection to precisely describe the various aspects associated with the concept of dose and how radiation energy deposited in tissue affects humans.

Absorbed dose is the amount of energy deposited in any material by ionizing radiation. The old unit of absorbed dose, the rad, (**R**oentgen **A**bsorbed **D**ose) is the dose delivered to anything which receives 100 ergs of energy deposited per gram of material. The new SI system unit is the gray (Gy). One gray equals 100 rads.

For purposes of radiation protection, 1 rad of photons is deemed to be equivalent to 1 R. The actual physical relationship is such that an exposure of 1 R would produce an absorbed dose of 0.87 air rads. If tissue were substituted for air at a point where the exposure to the air had been just measured to be 1 R, the tissue would receive an absorbed dose of 0.95 tissue rads. Thus the regulatory assumption of equivalence of 1 R and 1 tissue rad of photons is in error by only 5%.

2.9 Equivalent Dose

The equivalent dose is a measure of the effect which radiation has on humans. The concept of equivalent dose involves the impact that different types of radiation have on humans. Not all types of radiation produce the same effect in humans. The equivalent dose takes into account the type of radiation and the absorbed dose. For example, when considering beta, x-ray, and gamma-ray radiation, the equivalent dose (expressed in rems, **r**adiation **e**quivalent **m**an) is equal to the absorbed dose (expressed in rads) times a quality factor of 1. For alpha radiation, the equivalent dose is assumed to be twenty times the absorbed dose because the quality factor is 20. The new SI unit for the rem is the Sievert (SV). One sievert is equal to 100 rem.

Type of Radiation	Quality Factor (Q)
Alpha particles	20
Beta rays	1
Gamma rays	1
x-rays	1

Comparison of New and Old Units of Exposure and Absorbed Dose

	Exposure	Absorbed Dose	Equivalent Dose
Old Units	Roentgen (R)	rad	rem
New S.I. Units	None	Gray (Gy)	Sievert (Sv)
Comparison between old and new	None	100 rad = 1 Gy	100 rem = 1 Sv
For beta, gamma & x-rays: 1 rad x QF of 1 = 1 rem of exposure For alpha: 1 rad x QF of 20 = 20 rem of exposure			

2.10 Units of Activity

Activity represents the rate of radioactive decay of a sample. It represents the number of atoms decaying per unit time. The old unit for this quantity was based on the measured disintegration rate of one gram of the isotope Radium-226. It was called the Curie and represented 3.7×10^{10} disintegrations per second (dps). The new SI unit is the becquerel (Bq) which equals 1 dps.

Curie Units	Disintegrations/Second (dps)	Disintegrations/Minute (dpm)	Becquerel Units
1 Curie (Ci)	3.7×10^{10}	2.22×10^{12}	37 GBq (Giga Bq)
1 millicurie (mCi)	3.7×10^7	2.22×10^9	37 MBq (Mega Bq)
1 microcurie (uCi)	3.7×10^4	2.22×10^6	37 KBq (Kilo Bq)

Question: How many MBq are in 25 mCi of ¹¹¹Indium?
Solution: 1 mCi = 37 MBq, therefore 25 mCi x 37 MBq/mCi = 925 MBq

Question: How many millicuries (mCi) are in a package labeled as I-125 185 MBq
Solution: 185 MBq divided by 37 MBq = 5 mCi

2.11 Counting Efficiency

Not all radiation detection equipment is created equal. Many factors play a role in the equipments ability to detect known amounts of various types of radioactive material in sample tubes, on filter paper or in animal organs. A detector's counting efficiency is the ratio of the count rate to the disintegration rate, usually expressed as a percentage:

$$E = (R/A) \times 100$$

- E = counting system efficiency
- R = the net count rate in an individual measurement, counts per minute (cpm)
- A = activity of the radionuclide contained in the check source, (dpm)

Question: How do you convert your sample cpm to dpm using a known efficiency?

Solution: (Sample cpm – Background cpm) divided by efficiency = dpm

Example Problem: A tube containing iodine-125 was counted in a well counter. The net cpm count was 200 cpm (net = sample cpm - background cpm). If the well counter has an efficiency of 50% for iodine-125, how many dpm were in the tube?

Example Solution: 200 cpm divided by 0.50 equals 400 dpm in the tube.

2.12 Nuclide Safety Data Sheets

Nuclide safety data sheets for the more common nuclides used in research are available on line from many sources:

www.nchps.org

<http://nucleardata.nuclear.lu.se/nucleardata/toi/index.asp>

Each sheet provides physical data such as radiation energy, half-life, shielding and special precautions. The radiation worker should be familiar with each nuclide they intend on using.

SECTION 3.0 – PROCUREMENT OF RADIOACTIVE MATERIAL

3.1 Purchase Request For Radioactive Material

The Radiation Safety Office must be notified of all incoming radioactive packages. This can be accomplished by filling out the form entitled "Notification of Radioactive Material Shipment For Research Service" and delivering the form to room B017. Authorized users are responsible for not exceeding their approved possession limits of radionuclides. *(Note: If you are not sure of the authorized users approvals and possession limits, contact the RSO for a copy of the authorized users current permit.)*

Most Research authorized users have dual appointments at both the VA hospital and the University of Missouri. Radioactive shipments can be purchased with a University credit card, and shipped to the VA Hospital.

Radioactive material from the Missouri University Research Reactor (MURR) can be ordered by VA authorized users. Specific MURR forms must be completed by the authorized user prior to placing the order. Delivery of the shipments is provided by a private contract carrier arranged by MURR. Specific Department of Transportation (DOT) training is required for all personnel that transport radioactive hazardous material shipments.

Essential Isotopes operates the cyclotron that is located near MURR. They currently provide ¹⁸F-FDG to the Biomolecular Imaging Center. They maintain their own delivery service.

Radioactive material destined for the University of Missouri must be packaged in accordance with DOT regulations and coordinated through the University Environmental Health Service (EHS). Specific requirements should be discussed with the RSO prior to requesting the transfers.

3.2 Package Receipt and Inventory

As a general rule, all incoming shipments of radioactive material are delivered to the Radiation Safety Office for inspection and receipt. A radioactive package receipt record is completed by the Radiation Safety staff and includes an inventory log for use by the authorized user. Packages of radioactive material will then be delivered to the authorized user's laboratory and must be accepted by the authorized user or a radiation worker. If the authorized user or staff is not available, the contents of the package will be stored in accordance with the manufacturer recommendations in a secure location until such time that delivery can be accomplished. (Please note: The Radiation Safety Office no longer has the ability to store shipments that require refrigeration or freezer storage. The total activity used should be recorded for each isotope as the material is removed from the stock container. Completed log sheets **must be returned to the RSO** when the material is no longer needed or empty. Record a date to waste with a signature or initials of the person processing the inventory form. Return the form to B050. Failure to keep the authorized users inventory up to date may hinder future shipment delivery. Inventories should be updated at least monthly.

Incoming radioactive shipments are delivered to the Radiation Safety Office for inventory and leakage checks. If personnel from the Radiation Safety Office are not available on station, it is the responsibility of the authorized user or their radiation workers to collect the package from the warehouse and perform the appropriate package receipt steps. Some authorized users and their staff have been trained and authorized to receive their packages. Incoming radioactive shipments must be received in accordance with Department of Transportation regulations within 3 hours of receipt.

3.3 Transfer of Radioactive Material

All radioactive material that is transferred out of the hospital by vehicle must be properly packaged in accordance with the Department of Transportation (DOT) regulations. All packages of radioactivity leaving the hospital must be checked and approved by the Radiation Safety Officer and the institution receiving the material must be authorized. (This includes walking material from one institution to another) A copy of the receivers NRC or agreement state license must be on file prior to the shipment.

Arrangements must be made with the RSO in advance of any transfers to the University of Missouri or shipments to other licensed facilities. (See "Notification of Radioactive Material Shipment" - Radionuclide Transfer Section)

Transfers of radioactive material between authorized users is allowed as long as the receiving authorized user is approved for the specific nuclide. The transferring authorized user should note the transfer on their log sheet for that nuclide.

SECTION 4.0 – HANDLING RADIOACTIVE MATERIAL IN A LAB

4.1 General Rules For the Safe Use of Radioactive Material

Each authorized user and their workers should establish specific guidelines for the safe usage of radioactive material within the laboratory. Adherence to the following rules will provide a safe working environment for all personnel entering the area:

- Keep the laboratory clean and maintain uncluttered work areas.
- Wear laboratory coats or other personal protective equipment as required when using radioactive material.

- ❑ Wear disposable gloves at all times while handling radioactive material.
- ❑ Monitor hands while performing procedures and remove disposable gloves before leaving the lab.
- ❑ Do not pipette by mouth in radiation use areas.
- ❑ Do not eat, smoke or drink in radiation use areas.
- ❑ Do not store food or beverages in cabinets and refrigerators used for radioisotope storage.
- ❑ Label radioisotope containers and post radioactive signs on counter areas dedicated to radioactive use.
- ❑ Wear personal dosimeters at all times while in areas where radioactive materials are used or stored. These devices should be worn as prescribed by the RSO.
- ❑ Use appropriate shielding to reduce your radiation exposure and protect other workers from exposure.
- ❑ Volatile radioisotopes such as sodium iodide (I-125, I-131) in millicurie activities must be stored and used in fume hoods.
- ❑ Only dispose of radioactive waste in designated, labeled, and properly shielded receptacles separate from normal non-radioactive waste.
- ❑ Survey laboratory areas, equipment and personnel after each procedure utilizing radioisotopes. Document the survey results as required by the RSO.
- ❑ Know where the emergency spill procedures are posted and be familiar with their content.
- ❑ Know where the radioactive spill kit or supplies are located within your area.
- ❑ New workers should be supervised until their competency with radioactive material has been established.

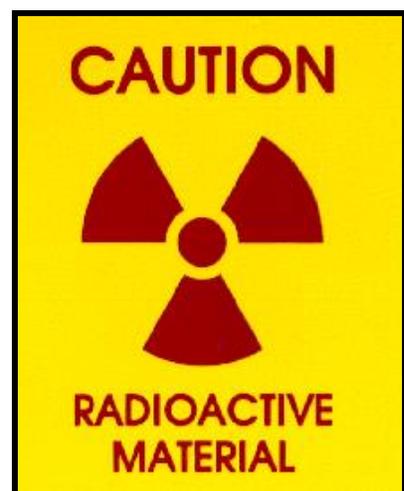
4.2 Posting of Warning Signs

Two different signs are conspicuously posted near the entrance to many of the research laboratories where radioactive materials are used or stored:

- Caution – Radioactive Materials
- Caution – Radiation Area

These signs are intended to inform individuals entering the rooms of a potential hazard, to restrict access to appropriate personnel and to denote radiological safety evaluation and control of the area.

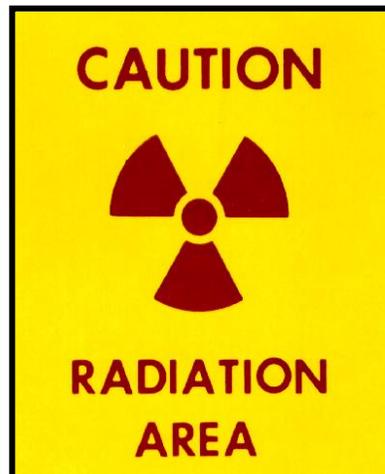
Laboratories which use or store radioactive material must be posted with a sign bearing the radiation symbol and the words "**CAUTION, RADIOACTIVE MATERIAL(S).**" The ambient radiation exposure in these areas is expected to be less than 5 mR/hr at 1 foot from the source.



There are some laboratories in which significant amounts of gamma-emitting radionuclides are used such that the potential exists for an individual to incur more than 5 mR in one hour (5 mR/hr) at a distance of 30-cm (one-foot) from the source. The entrance to these areas will be posted with a sign bearing the radiation symbol and the words "CAUTION, RADIATION AREA".

Laboratory doors posted with radioactive signs are considered restricted areas and subject to specific regulations. Personnel entering these posted areas must be escorted or provided information as to what type of exposure they may encounter.

Non-radiation workers or escorted visitors must not be exposed to more than 2 mR in any one hour. (For example, if the exposure rate was 8 mR/hr, their time in the area must be limited to 15 minutes or less.)



4.3 Opening Containers of Radioactive Material

Check the integrity of each source container. Look for broken seals or vials, loss of liquid, condensation, or discoloration of packaging material. If anything is other than expected, stop and ask for help from the laboratory supervisor or the RSO. Monitor the packing material and the empty packages for contamination with an appropriate detection instrument prior to discarding. **If the packing material is free of contamination, remove or obliterate the Department of Transportation hazardous material labels from the two sides of the box before discarding in the normal trash.**



4.4 Storage and Control of Radioactive Material

Control of radioactive material to prevent unauthorized removal or access is a high priority of regulatory inspectors. Laboratory staff **must** be familiar with the laboratories radioactive material inventory and how security of that material is maintained. Security of radioactive material can only be demonstrated by the following methods:

- The worker maintains constant surveillance of the radioactive material in use, or
- The laboratory door(s) are locked when no one is in the area, or
- The radioactive material is locked in a cabinet or refrigerator to prevent removal.

4.5 Security of Research Laboratories

Access to research hallways ("A", "B" and "F" quadrants) are controlled by magnetic key cards issued by the Research Office. These access doors are to remain closed at all times. If you find the doors open, please close it behind you. Report suspicious people and packages to your supervisor, the RSO or the Police (extension 56320).

Hospital policy requires all VA and WOC staff to prominently display a VA photo identification card at all times while in the Medical Center's Research area. The Police routinely tour the areas and will ask for VA IDs. Personnel found within the research areas without proper identification will be identified and may be required to leave the area.

The authorized user and their radiation workers are responsible for maintaining security of the radioactive material in their possession. Control of radioactive material can be demonstrated by one of two methods: (1) direct surveillance or (2) under lock and key. If an inspector can gain access to your laboratory and radioactive material without being challenged, you do not have control of the material. Discuss with your supervisor, what security methods are used for the areas you will be working in. Never assume the magnetic door locks on the hallway entry doors are always secure.

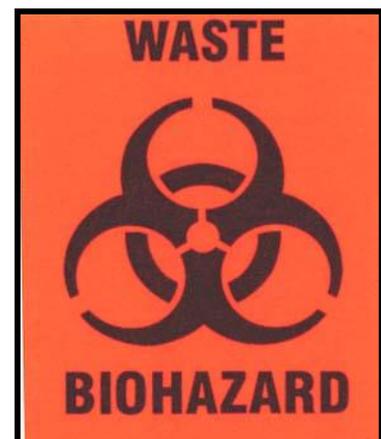
Many research programs utilize some form of animal model in their research. All VA and WOC staff must be alert to the fact that there are organizations apposed to any form of animal research and will do anything to disrupt these programs. The VA Medical Center is not immune from these attempts. Recently personnel have made multiple attempts to gain entry to these areas. Report all suspicious activity to the VA Police immediately.

4.6 Use of Radioactive Materials in Animals.

The Radiation Safety Committee must approve protocols involving the use of radioactive material in animals. The animals must be housed in a separate area designated and posted as a radiation area. Animal excreta and carcasses must be handled as radioactive material and precautions taken to reduce radiation exposure and personnel contamination. The authorized user or their radiation workers are responsible for disposal of excreta and carcasses containing radioactivity as outlined in "Standard Procedures and Protocols for Using Radioactive Material in Animals" which can be obtained from the Radiation Safety Office. Several freezers located in room A029 are maintained by the Radiation Safety Office to store radioactive dead animal carcasses. Animal carcasses must be properly bagged and labeled with the following information.

- ❑ Date of most recent injection of radioactive material
- ❑ Radionuclide and approximate total activities contained in the bag
- ❑ Person's last name that packaged the animals for disposal
- ❑ Type of animal carcass(s) (i.e. 5 mice or 3 rats)
- ❑ Other hazard labels: Biohazard Waste, Chemotherapy Waste (Can be labeled separately or attached to the back of the radioactive tag)

Experimental animals that have been infected with human cancer cells or infectious agents and contain radioactive material must be placed in biohazard bags OR a biohazard label is attached to the back of the radioactive material tag. Animals infused with chemotherapy drugs must be labeled as chemotherapy waste and include the specific drug name. Both the animal carcasses and the cage litter must be labeled as chemotherapy waste. The label below and to the right are examples of appropriate labels that must be attached to the animal or litter bags of waste.



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Room A029 contains one upright freezer for short half-life isotopes (T1/2 <9 days) and one upright freezer for long half-life carcasses such as Iodine-125, Hydrogen-3 and Carbon-14. Log-in sheets are located with the freezer for recording all animals placed within the freezer. A third small freezer is for non-radioactive dead animals. This freezer and its contents are handled by the Office of Animal Research (OAR) personnel. Problems with this freezer should be directed to the OAR staff or the Research Office.

4.7 Radiation Safety Enforcement Policy

The goal of the radiation safety program is to maintain a safe working environment, and to prevent incidents that could result in violations being cited against this medical center. The Medical Center's Master Material License Permit allows each licensee to be self-regulatory; correcting programmatic deficiencies in an appropriate and effective manner as they arise. During quarterly inspections, the Radiation Safety staff will evaluate the radiation safety program of each research user for compliance with the policies set forth in this safety manual. Deficiencies identified during an inspection will be documented. If successive deficiencies are identified, progressive enforcement actions will be instigated by the RSO and the Radiation Safety Committee. Failure to correct deficiencies will cause the termination of the authorized users radioactive material permit and right to possess radioactive material.

RADIATION SAFETY ENFORCEMENT POLICY

Deficiency Level	Type / Examples	Corrective Action By AU	RSO / RSC Follow-up Action
Level 1 SERIOUS	Major loss of program control; e.g., <ul style="list-style-type: none"> - Lack of control of radioactive material, - Spread of contamination to unrestricted areas, - Any NRC reportable event, - Personnel exposure in excess of limit - Willfully providing false information or data to an inspector - Escalation of Level 2 	Immediate cessation of operations <ul style="list-style-type: none"> - AU must respond to RSO's findings in writing: - Reason for the violation, <u>or</u> - If contested, the basis for disputing the violation, - Corrective steps that have or will be taken to prevent reoccurrence. 	RSO notifies the RSC chairman / Director: <ul style="list-style-type: none"> - Notify VHA NHPP if required - The AU must report to the RSC - The RSC may suspend authorization for a specified period of time.
Level 2 MAJOR	Major program violations: e.g., <ul style="list-style-type: none"> - Evidence of eating and/or drinking in restricted area, - Major contamination, - Spread of contamination, - Program violation due to inadequate personnel training, - No surveys performed for more than 3 months, - Security violation where access to radiological items or sources presents exposure risk to public >2 mR/hr. - Falsification of Records - Failure to provide complete information to inspector/auditor - Escalation of Level 3 	AU must respond to RSO's findings with corrective actions in writing: <ul style="list-style-type: none"> - Reason for the violation, or - If contested, the basis for disputing the violation, - Corrective steps that have or will be taken to prevent reoccurrence, - The date when full compliance will be achieved. 	RSO notifies the RSC chairman <ul style="list-style-type: none"> - RSC may temporarily suspend the AU's authorization or limit specific aspects of the approval.

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	<p>Minor program violations: e.g.,</p> <ul style="list-style-type: none"> - Improper waste storage or identification - Failure to perform prescribed area surveys - Minor contamination found during inspection which was unidentified by AU's surveys, - Improper ordering of radioactive material, - Failure to provide or use proper shielding to keep exposures ALARA, - Failure to institute corrective actions to prevent re-occurrence of previously identified problems, - Security violation where access to significant items presents exposure risk to public, but <2 mR/hr, - Escalation of Level 4 	<p>Immediate response to correct if possible; or correct deficiency within specified time frame</p>	<p>RSO verifies and documents corrective action.</p> <p>Deficiency reported to RSC at next regular meeting.</p>
	<p>Administrative; e.g.,</p> <ul style="list-style-type: none"> - Poor or incomplete record keeping of surveys, inventory, - Minor deficiencies immediately corrected, - Security violation, but no significant exposure risk to public. 	<p>AU will complete or correct deficiency</p>	<p>RSO verifies and documents corrective action during next audit.</p>

Self-identification and correction is encouraged by the RSO. Self-identified deficiencies reported to the RSO by a radiation worker will not be cited if proper corrective action is immediately taken and the original problem is not repeated. The entire Radiation Safety Committee's Enforcement Policy is located in the manuals attachments.

SECTION 5.0 – CONTROL OF EXTERNAL EXPOSURE

5.1 Fundamental Principles of Radiation Protection

Protection against radiation from either devices or radioactive material requires an understanding of the particular characteristics of the radiation involved. There are certain fundamental principles of radiation protection that should be understood by anyone who might be exposed to radiation. These involve the protection that can be provided by time, distance and shielding.

5.2 Time

When exposed to radiation at a constant rate, the total dose equivalent received depends on the length of time exposed. If an unshielded radioactive source produces a radiation level in a work area of 2 mrem per hour (mrem/hr), an individual who works in that area for 40 hours per week would receive approximately 80 mrem for each week worked. Thus, controlling the time of exposure can control the amount of radiation received.

5.3 Distance

If the distance from a point source of radiation is doubled the exposure is quartered. (i.e., a person standing 4 meters from a radiation source will be exposed to only ¼ as much radiation as a person standing 2 meters from the source). This relationship describes the Inverse Square Law. The exposure rate from a point source of radiation is inversely proportional to the square of the distance from

the source. Thus, controlling the distance from a source of radiation can also control the amount of radiation received.

5.4 Shielding

Radiation interacts with any type of material and the amount of radiation is reduced on passage through materials. Thus, materials can be used to shield against radiation. However, some materials (e.g., lead or concrete) make more efficient shields than others. Generally, in choosing shielding one must consider the type and energy of radiation involved.

There are basically three emissions from radionuclides - alpha particles, beta particles, and gamma rays. Alpha particles can be halted by a sheet of paper. A beta particle can be absorbed by an inch of wood or a ¼ inch of plastic. The gamma rays are typically stopped by lead or concrete. High-energy beta particles interacting with lead (high Z material) will cause bremsstrahlung photons (x-rays) to be produced. While just a few millimeters of most solid material will stop beta particles, low Z material (e.g., plastic, regular glass) will produce significantly less bremsstrahlung than high Z material (e.g., lead or leaded glass). The most effective shielding incorporates the use of a plastic container to absorb beta particles and encase the plastic in lead to absorb the bremsstrahlung.

SECTION 6.0 – RADIATION EXPOSURE MONITORING

6.1 External Personnel Monitoring

Personnel that are required to work with or in the vicinity of radioactive material are considered occupational workers, and as such may require monitoring for radiation exposure. If it is anticipated that the worker is likely to receive a dose in excess of 0.5 rem in 1 year from sources external to the body, a monitoring dosimeter must be issued and worn (10% of the established limits 10 CFR 20.1502).

External monitoring is performed using the Landauer optically stimulated luminescence technology. The whole body badges are sensitive to 1.0 mrem for gamma and x-rays and 10 mrem for energetic beta (>1MeV) for the wear period (monthly).

Dosimeters are issued by the Radiation Safety Office. **Personnel issued dosimeters are required to wear them at all times while at work. The dosimeters are used to monitor your occupational exposure while working with or in the vicinity of radioactive material.** Dosimetry reports are on file in the Radiation Safety Office and a duplicate report is made available to researchers about 3 to 4 weeks following the wear period. Ask your supervisor where the reports are posted.

The "F" quadrant radiopharmaceutical Sciences Institute (RSI) area has been designed for using large activities of radioactive material for radiopharmaceutical research and the Biomolecular Imaging Center (BIC). **Wholebody dosimeters are required for research personnel routinely working with gamma and high energy beta emitters.** Hand monitoring dosimeters are required for personnel working with high energy beta and gamma radionuclides. All dosimeters are exchanged on the first of each month. Ring monitors are available in small, medium and large sizes. Visitor badges are available from the RSO.

6.2 Internal Personnel Monitoring

Research personnel working with high levels of uncontained radioactive material such as iodine-125 and hydrogen-3 maybe required to have bioassays performed. A thyroid bioassay (if required) should be performed after waiting at least 6 hours, but not more than 72 hours following the exposure.

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Table 6.2-1 sets the activity levels above which bioassays for iodine-125, iodine-131 and tritiated compounds are required.

For example, if 1 mCi of sodium iodide is used in a fume hood to perform a protein iodination, the worker should have a thyroid bioassay analysis performed the next day but not more than 3 days later. The RSO can perform this procedure in less than 5 minutes and it is the radiation workers responsibility to have the thyroid bioassay done.

When tritium (H-3) is used in uncontained form, a routine bioassay (urine sample) is necessary when quantities of tritium processed by an individual at any one time or the total amounts processed per month exceed those limits shown in Table 6.2-1 for each form of tritium. A bioassay is also required when an employee comes into skin contact with, ingest, or absorbs into the body through cuts, abrasions, or accidental (hypodermic) injection, water or any other substance with concentrations of tritium greater than or equal to 0.01 uCi/cc. A baseline bioassay of each worker is required before that worker begins working with tritium in amounts that would require initiation of a bioassay program. When required, a bioassay will be performed within one week for a single contact or weekly for continuous contact.

Table 6.2-1. Activity Levels Above Which Bioassays Are Required

TYPES OF OPERATION	ACTIVITY HANDLED IN UNSEALED FORM		
	Volatile or Dispersible Iodine	Iodine Bound to Nonvolatile Agent	Tritiated Water or Compounds
Processes are carried out in an open room or bench with possible escape from process vessels.	0.1 mCi	1 mCi	10 mCi
Processes with possible escape are carried out within a fume hood of adequate design and face velocity.	1 mCi	10 mCi	100 mCi
Processes are carried out in a glove box that is ordinarily closed.	10 mCi	100 mCi	1,000 mCi

Air sampling may be used to determine whether the confinement of radioactive materials is effective, to measure airborne radioactive material concentrations in the workplace, to estimate worker intakes, to determine posting requirements, and evaluate what protective equipment is appropriate.

6.3 Radiation Dose Limits

Title 10 CFR 20.1201 establishes radiation dose limits for occupationally exposed adults. These limits apply to the sum of the dose received from external exposure and the dose from internally deposited radioactive material. Dose limits represent an acceptable level of potential risk and do not represent a level that will necessarily be unsafe if they are exceeded.

Annual Limits For Occupational Workers (Adults)

Total effective dose equivalent (whole body)	5 rem	0.005 Sv
Dose to the lens of the eye	15 rem	0.15 Sv
Total dose to any single organ or tissue	50 rem	0.5 Sv

The occupational dose limits for minors (<18 years of age) is 10% of the dose limits for adults. A declared pregnant worker has a dose limit for the embryo/fetus of 0.5 rem per gestational period (9 months) with no more than 0.05 rem in any one month. A declared pregnant worker means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

6.4 Public Dose Limits

Authorized users must ensure that licensed material will be used, transported, stored, and disposed of in such a way that members of the public will not receive more than 100 mrem (1 mSv) in one year from licensed activities. A "Member of the Public" is defined in 10 CFR Part 20 as "any individual except when that individual is receiving an occupational dose." The public which includes visitors to the lab cannot be exposed to more than 2 mrem in any one hour from licensed operations and must be escorted at all times while in the restricted areas.

6.5 ALARA Program

The concept that exposures to individuals and groups should be kept "**As Low As Reasonably Achievable**" (ALARA) has been an operating principle of the radiation safety program of this Medical Center for many years. The dose limits discussed in section 6.3 are based on limiting dose to what is considered to be an acceptable level of risk to the exposed individual. Still, any radiation exposure may carry some risk. Thus, the NRC requires licensees to take actions, to the extent practicable, utilizing procedures and engineering controls to further reduce the risk and keep exposures ALARA.

SECTION 7.0 – LABORATORY SURVEYS

7.1 Ambient Radiation Level Surveys

Dose-rate surveys with a GM detector should be performed in locations where workers are exposed to radiation levels that might exceed 2 mR/hr.

7.2 Contamination Surveys

Contamination surveys should be sufficient to identify areas of contamination that might result in doses to workers or to the public. Combined removable and fixed contamination should be surveyed using appropriate radiation detection equipment. Removable contamination can be detected and measured through a wipe test of the surface, which is counted in an appropriate counting instrument, such as a liquid scintillation counter, a sodium iodide or gamma well counter.

7.3 Survey Frequency

The minimum required survey frequency is established by the Radiation Safety Committee and is based upon the radiotoxicity group of the isotope, how much activity will be used daily or weekly and the radiation safety record of the authorized user. Typical survey frequencies are illustrated in the table below:

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Radiotoxicity Group	Nuclide	Recommended Minimum Survey Frequency		
		Monthly	Weekly	Daily
1	Pb-210, Ra-226, U-234, Am-241	< 10 uCi	< 100 uCi	> 100 uCi
2	Cl-36, Ca-45, I-125, I-131, Cs-137, Bi-210, Ac-225	< 200 uCi	< 1 mCi	> 1 mCi
3	C-14, F-18, P-32, S-35, Cu-64, Y-90, In-111, Lu-177, Re-188, Bi-212, Bi-213, Pb-203	< 1 mCi	< 10 mCi	> 10 mCi
4	H-3, Tc-99m	< 10 mCi	< 100 mCi	> 100 mCi

The authorized user is responsible for all necessary area surveys being performed correctly and on time. The Radiation Safety Staff will check laboratory surveys on at least a quarterly basis during unannounced audits. Survey forms for specific labs are available from the Radiation Safety Officer or the radiation worker may prepare their own. The survey record of the dose rate and removable contamination must include the following information:

- The date, area surveyed, and equipment used (GM dosimeter, Liquid Scintillation Counter)
- The name or initials of the person who made the survey.
- A drawing of the areas surveyed with contamination and dose rate levels indicated.
- Measure dose rates in mR/hr and /or contamination levels in dpm/100 cm², as appropriate.
- Indicate actions taken in the case of excessive dose rates or contamination and results of the follow-up survey (Survey Action Form).

Laboratories not actively using radioactive material for a period of time do not have to perform surveys of the laboratory. The survey records should indicate these times when no activity has been used. **Monthly surveys of storage areas are required where stock solutions of radioactive material are kept, such as a refrigerator or fume hoods. Only those storage areas need to be surveyed.**

The radiation worker should refer to the authorized users permit for specific survey requirements.

Survey Frequency Examples:

Example 1. A worker handling 250 uCi of H-3 each week is required to perform a monthly swipe survey using liquid scintillation counting. The use of a GM meter is not indicated since its energy is too low for the meter to detect.

Example 2. A group of radiation workers in a lab handle 50 mCi of Technetium-99m, 10 mCi of Fluorine-18 and 100 mCi of Lutium-177 in a week. They must perform a daily, end-of-day survey with a GM detector and a weekly swipe survey for removable contamination to be compliant with the Medical Center's Master Material License.

7.4 Radiation Detection Equipment Selection

Low-energy beta emitters, such as carbon-14 and sulfur-35, are difficult to detect with Geiger-Mueller (GM) probes. The detection efficiency generally is about 2% for low-energy beta emitters. The proper surveying method (e.g., speed and height above surface) is important to perform adequate surveys. Additionally, wipes should be taken and counted on a liquid scintillation counter to verify

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potential contamination. **Hydrogen-3 is a very low energy beta emitter (38 keV) that will not penetrate a person's skin and cannot be detected with a GM survey meter.** Swipe samples analyzed on a liquid scintillation counter is the only reliable detection method.

Medium to high-energy beta emitters, such as phosphorus-32 and calcium-45, can be detected with a pancake GM. The efficiency ranges from 15% to 40%, depending on the beta energy.

Low-energy gamma emitters, such as iodine-125, can be detected with a sodium iodide (NaI) probe or a thin window GM probe (pancake or thin end-window). If the sodium iodide probe possesses a thin window and thin crystal, the detection efficiency is approximately 20%. If a pancake or thin end-window GM probe is used, the detection efficiency is significantly lower and care should be taken to ensure that the GM probe is capable of detecting the trigger levels (200 dpm).

Medium- to high-energy gamma emitters, such as Iodine-131, can be detected with either GM or sodium iodide probes, depending on the required sensitivity. In general, the sensitivity of GM probes is much lower than for sodium iodide probes.

The following table may be helpful in selecting instruments:

Portable Survey Instruments Used for Contamination and Ambient Radiation Surveys			
Detector	Radiation	Energy Range	Efficiency
Exposure Rate Meters	Gamma, X-ray	mR - R	N/A
GM Count Rate Meters	Alpha	All energies (dependent on window thickness)	Moderate
GM Count Rate Meters	Beta	All energies (dependent on window thickness)	Moderate
GM Count Rate Meters	Gamma	All energies	< 1%
NaI Scintillator	Gamma	All energies (dependent on crystal thickness)	Moderate
Plastic Scintillator	Beta	Carbon-14 or higher (dependent on window thickness)	Moderate

Stationary Instruments Used to Measure Wipe, Bioassay, and Effluent Samples			
Detector	Radiation	Energy Range	Efficiency
Liquid Scintillation Counter	Alpha	All energies	High
Liquid Scintillation Counter	Beta	All energies	High
Liquid Scintillation Counter	Gamma		Moderate
Gamma Counter (NaI)	Gamma	All energies	High
Gas proportional Counter	Alpha	All energies	High
Gas proportional Counter	Beta	All energies	Moderate
Gas proportional Counter	Gamma	All energies	< 1%

7.5 Radiation Detection Survey Meters

Every laboratory should have a survey meter or laboratory monitor readily available that is capable of detecting radiation from material in use. Laboratories using small activities of weak beta emitters such as Hydrogen-3 (³H), Carbon-14 (¹⁴C) are exempt from this requirement. Survey meters used for area monitoring must be calibrated annually by an approved method. The individual using the survey meter is responsible for ascertaining that the unit is functioning properly before proceeding with the survey. The RSO can provide annual calibration of the GM Survey meters (for free) or the investigator can send the meters out for calibration.

Recommended survey meter: Ludlum Model-3 GM with a Model 44-9 pancake probe. The unit should also have a self contained radioactive check source attached to the unit.

What is the proper procedure for checking a survey meter before using it?

- Check the meter calibration sticker date (must be within 1 year)
- Check the battery charge level
- Check the exposure rate of the check source to make sure it is reading the same as when it was calibrated (+/- 20%).

How do you survey a lab with the survey meter?

- Hold the pancake probe 1 cm from the surface you are surveying, moving it slowly, and listening for the clicks of possible contamination.
- Survey all areas where the radioactive material was used and record your findings on an appropriate survey log in mR/hr,
- When established action thresholds are exceeded, contact your lab supervisor, or the RSO.

Area surveys with a GM detector are used to detect spots of contamination, or radioactive material left in inappropriate locations. Each radiation worker should make an effort to keep their exposure and that of fellow workers ALARA. Each worker should routinely check their lab coats, hands and feet with the survey meter before leaving the area. The following criteria have been established as guidance for radiation workers performing area surveys.

Exposure rates at close proximity (1 cm) to a contaminated spot with a suitable GM detector should be addressed as follows:

- <1.0 mrem/hr, no action indicated.
- >1.0 mrem/hr, See instructions for cleaning a minor radioactive spill.
- >100 mrem/hr, Contact Radiation Safety Officer for clean-up support and advice.

General area exposure rates to the whole body are measured 30 cm from the source:

- <0.1 mrem/hr, no action indicated.
- >0.1 mrem/hr, limit work to shorter periods.
- >1.0 mrem/hr, consider shielding to reduce exposure.
- >5.0 mrem/hr, "Radiation Area" contact Radiation Safety Office for advice and correct door posting.

7.6 Assessing Removable Contamination

The purpose for controlling the level of removable surface contamination is to minimize the spread of contamination and to limit the potential for personnel contamination and inhalation dose from the re-suspension of surface contamination.

How does one take a smear?

The amount of removable material per 100 cm² of surface area should be determined by wiping an area of that size (4" x 4") with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an instrument of known efficiency. The swipe results must be recorded in disintegrations per minute (dpm). The following action levels are established for restricted and unrestricted areas:

**Recommended Action Levels in dpm/100 cm² for
Removable Surface Contamination**

Contamination Source	Restricted Areas	Unrestricted Areas
I-125	200	20
I-131	2,000	200
Beta-Gamma Emitters	20,000	1,000

When the above action levels are exceeded, decontamination of the affected area is required by the radiation worker. If contamination levels continue to exceed the action levels, immediately contact the Radiation Safety Officer.

7.7 Incidents of Contamination

Contamination is defined as the deposition or presence of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful. Routine area surveys with a GM detector or swipe surveys will disclose minor contamination when performed properly. Minor contamination when discovered should be corrected and documented in the survey log. Self identification and correction by the radiation worker is encouraged by the RSO and will not be cited as a deficiency.

7.8 Emergency Spill Procedures

A radioactive spill is defined as an uncontrolled release of radioactive material. The spill may involve fire or volatile solvents and requires immediate action to be taken to limit the spread of the radioactive material and limit personnel access to the contaminated area. Emergency procedures are posted in each laboratory utilizing radioactive material and in the Attachments of this manual. Each worker should be familiar with the emergency response procedure.

The decision to implement a minor or major spill procedure depends on many incident-specific variables such as:

- Number of individuals contaminated
- Location of spill (unrestricted public areas such as hallways or restricted labs)
- What other hazards are present (chemical fumes or biohazards)
- What is the likelihood the contamination will be spread to other areas

- ❑ What types of surfaces are contaminated (counter or floor)
- ❑ What is the radiotoxicity of the material spilled

If you have doubts about how to proceed with the cleanup, stop and talk to your lab supervisor, authorized user or the Radiation Safety Officer. Every radiation worker has experienced some type of radioactive material spill during his or her career. Remember that self-identification and correction (decontamination) is what is expected of each radiation worker and is viewed as a proper response by the RSO and regulatory inspectors.

7.9 Decontamination of Personnel

Decontaminate personnel by removing contaminated clothing and flushing contaminated skin immediately with lukewarm water followed by washing with mild soap. If the contaminated individual is injured, the first consideration should be to seek medical attention for the injury victim and notify the medical staff of the possible contamination. Contact the Radiation Safety Officer as soon as possible.



SECTION 8.0 – RADIOACTIVE WASTE DISPOSAL

8.1 General Requirements

Radioactive waste generated by Research workers must be transferred to the Radiation Safety Office for disposal. Radiation Safety staff will make waste pickups from the laboratories every Monday between 8:00 and 9:00 AM. The waste must be packaged appropriately for pickup. Containers of waste should be kept inside of the laboratory until collected by the RSO. Research personnel must not place waste containers within the hallway unless the licensed material is under their constant surveillance.

A new waste management system is mandated by the Department of Veterans Affairs called the "Green Environmental Management System", (GEMS), which coordinates all waste production and disposal of all hazardous material within the Hospital. The management system includes routine audits by the GEMS committee and outside audits by compliance inspectors and EPA. The goal of the program is to reduce the hazardous material generated, to protect hospital personnel, the public and the environment from hazardous material.

8.2 Radioactive Waste Containers

Radioactive waste containers are provided by the Radiation Safety Office in the form of yellow 5-gallon buckets for dry waste and plastic or glass 1-gallon containers for liquids. An assortment of lead pigs can also be obtained from the RSO. All radioactive waste containers must be clearly identified as such and will include the isotope that it contains. Appropriate shielding of waste containers is the responsibility of the authorized user. Do not place radioactive waste containers near the normal waste containers. Waste containers should be shielded, so the surface exposure does not exceed 2 mR/hr. Acrylic shields for high-energy beta



emitters must be purchased by the authorized user.

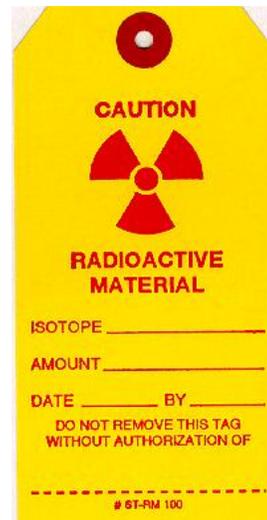
8.3 Solid Waste

Initial segregation of low level radioactive waste (LLRW) should be by isotope or physical half-life for purposes of disposal. Short half-life material (< 9 days) such as Tc-99m, In-111, Lu-177 can be combined into one solid waste container if approved by the RSO.

Dry waste such as paper, plastic, disposable gloves and glass tubes should be sealed in a clear plastic bag with a **radioactive tag** stating the isotope, approximate activity (uCi) or exposure rate, and the date sealed.

Sharps such as hypodermic needles and syringes contaminated with biohazard waste should be packaged in a sharps (red) container. Short half-life (<120 days) dry medical waste should be double bagged and the outermost bag should be labeled as biohazard waste.

Long half-life material such as H-3 and C-14 must be shipped for disposal. The dry waste should be placed in clear plastic bags and labeled with a radioactive material tag. Sharps such as needles and Pasteur pipets must be placed in a sturdy container such as a plastic jug. **Do not use a medical sharps box for non-hazardous sharps.** Radioactive waste vendors are not allowed to pickup medical waste or red needle boxes no matter what the contents are.



Discuss your proposed waste stream with the RSO, who can recommend the best and cost effective solutions.

8.4 Liquid Scintillation Vials

Liquid scintillation vial (LSV) waste must be separated by isotope in leak proof containers. **Only biodegradable liquid scintillation cocktail is allowed** for Research use. Bags of scintillation vials being readied for waste pickup must be identified with a proper radioactive tag indicating the radionuclide, approximate total activity, date, and the approximate number of scintillation vials contained within the bag.

The use of non-hazardous liquid scintillation cocktail for experimental work decreases the amount of mixed waste produced and the cost of disposal. The following list of liquid scintillation cocktails are considered "non-hazardous" by the Federal EPA as of 2003.

Manufacturer	Product
Packard Instruments	Ultima Gold, Ultima Gold AB, Ultima Gold LLT, Ultima Gold MV, Ultima Gold XR, Ultima Flo AF, Ultima Flo AP, Ultima Flo M, MicroScint 40, Emulsifier Safe, MicroScint O, MicroScint 20, Opti-Fluor, Opti-Fluor O.
Research Products International	Bio Safe NA, Bio Safe II, Econo-Safe.
Perkin Elmer	OptiPhase Supermix, OptiScint HiSafe, OptiPhase HiSafe 2, OptiPhase HiSafe 3, OptiPhase Polysafe, Formula-989.
ICN Radiochemicals	Universal ES, BetaMax ES, Ecolume, Ecolite(+), CytoScint ES.
Amersham	BCS Scintillation Cocktail, BCS-NA Scintillation Cocktail.

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Manufacturer	Product
Fisher Scientific	ScintiSafe Econo, ScintiSafe Econo F, ScintiSafe Gel Cocktail, ScintiSafe 30% Cocktail, ScintiSafe Plus 50% Cocktail, Scintiverse BD.
National Diagnostics	Ecoscint, Econscent A, H, O.

Liquid Scintillation vials are classified as either deregulated or regulated waste. Deregulated scintillation vials consist of Hydrogen-3 or Carbon-14 only with total activity less than 0.05 microcuries per milliliter of cocktail. All other scintillation vials are considered regulated waste. The radiation worker preparing liquid scintillation vials for disposal must be able to provide an explanation on how the total activity was determined on the radioactive waste tags.

8.5 Liquid Radioactive Waste

Aqueous liquids containing radioactive material are generally comprised of culture medium, buffered wash solutions etc. that do not contain any organic solvents. Any solids contained within the waste must be readily soluble (or readily dispersible biological material) in water. The Radiation Safety Office provides sturdy one-gallon plastic waste jugs for aqueous waste.

It is the responsibility of the individual placing the first drop of radioactive liquid into the empty jug to indicate the radionuclide on a radioactive label or tag. In addition to the radioactive material tag, the chemical contents of the jug must be noted on the container. Special high activity radioactive waste should be placed in smaller containers to facilitate shielding during the decay process.

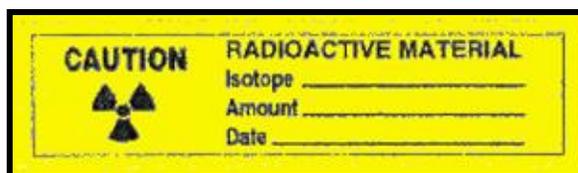


Waste label example: A radioactive label on the waste jug indicates "Tc-99m" when the first drop was placed in the jug. The chemical label on the jug could look like one of the following examples:

Hazardous Material
Start Date: 6/1/2015
50 mM Phosphate Buffered Saline, pH 7.4

OR

Hazardous Material Start Date: 9/1/2016
30% Acetonitrile
0.1% Trifluoroacetic Acid (TFA) in water.



Organic solvents containing radioactive material must be labeled with the radionuclide, activity and the percent of each organic solvent present. The storage container must be appropriate and non-reactive with the organic solvents, but no larger than one gallon. The container should not be filled more than three-fourths full. Glass waste jugs maybe available from the Radiation Safety Office for organic solvents. Check with David Bellamy for availability.

Contact the Industrial Hygienist (x56307) when there are questions about mixing many different organics in one container. **Ask first before mixing everything together.**

8.6 Regulated Medical Waste

The medical waste hauler, Stericycle, will accept those medical wastes generated in the diagnosis, treatment or immunization of human beings or animals or related research. The term "medical waste" includes wastes, which are generated in the production or testing of biological products and the preparation and administration of chemotherapy agents. For the purpose of this document "medical wastes" also mean, biohazardous, biomedical, or regulated medical waste, as those terms are defined under federal, state or local laws, rules, regulations and guidelines.

Infectious Waste

Laboratory Waste: Cultures - medical / pathology, Cultures - stocks of infectious agents, (i.e., World Health Organization Risk level I, II, III), Vaccines and vaccine production related waste, Microbiological specimens and related waste.
Pathological Waste: (no preservative agents such as formaldehyde): Tissues, Amputated limbs, Organs, Surgical specimens.
Research Waste: (animal): Tissue, Carcasses, Organs, Body fluids.
Fluids: Blood/blood products, Equipment / articles contaminated with blood and/or blood products.
Infectious Waste, (not limited to isolation waste), contaminated with: Excretions, Exudates, Secretions, Body fluids.
Contaminated Sharps: (NO LOOSE SHARPS) Needles, Syringes, Scalpel blades, Needles with attached tubing, Dental wires, Disposable surgical instruments, Slides, Pipettes, Blood tubes or vials, Contaminated broken glass.

Chemotherapy (antineoplastic / cytotoxic drugs) Waste

Chemotherapy waste: Gowns, Gloves, Masks, Barriers, IV tubing, Empty bags/bottles, Needles and syringes, Empty drug vials, Spill kits.
Warning
Intravenous tubing, bags, bottles, vials and syringes incidental to the preparation and administration of chemotherapy drugs must be "EMPTY", containing only residual amounts of antineoplastic drugs (less than 3% by weight of the total capacity)

Chemotherapy drug bottles or vials that contain more than 3% of their total volume in drug must be handled as hazardous chemotherapy waste and given to the Industrial Hygienist for disposal.

8.7 Animal Waste

Animal remains should be wrapped in absorbent material and placed in the appropriate radioactive freezer in A029 for further processing by the RSO. Each bag of waste must have the radionuclide, activity injected, the number of animals (i.e. 5 mice), and the date recorded on the radioactive material tag attached to the bag. **Do not use radioactive material tape to seal the bag or label it.** Tape labels do not always stay on the bags when they are placed in the freezer. Record the necessary information on the log sheet located on the freezer. Animals that have been infected with human derived cancer cells or infectious material must be placed in a bag or container that indicates "biohazard" on its exterior or the back of the radioactive material tag. A biohazard self stick label is easily placed on the back side of the radioactive material cardboard tag. Clear biohazard bags can also be used with the radioactive tag.



SECTION 9.0 – RADIATION AND RISK

9.1 Biological Effects of Radiation

See U.S. NRC Fact Sheet in attachments entitled "Biological Effects of Radiation." A printed copy can be obtained at:

<http://www.nrc.gov/reading-rm/doc-collections/fact-sheet/bio-effects-radiation.pdf>.

Additional information can be found from:

The National Academy of Sciences, Beir VII: Health Risks from Exposure to Low Levels of Ionizing Radiation at www.nap.edu

U.S. Environmental Protection Agency, "Radiation Risks and Realities" May 2007, EPA-402-K-07-006 at website: www.epa.gov/radiation

9.2 Prenatal Radiation Exposure

The Centers for Disease Control and Prevention (CDC) have prepared the following information to help you understand the possible health effects to your unborn baby from exposure to radiation.

The exposure of an unborn baby to radiation is referred to as prenatal radiation exposure. This can occur when the mother's abdomen is exposed to radiation from outside her body. Also, a pregnant woman who accidentally swallows or breathes in radioactive materials may absorb that substance into her bloodstream. From the mother's blood, radioactive materials may pass through the umbilical cord to the baby or concentrate in areas of the mother's body near the womb (such as the urinary bladder) and expose the unborn baby to radiation.

The possibility of severe health effects depends on the gestational age of the unborn baby at the time of exposure and the amount of radiation it is exposed to. Unborn babies are less sensitive during some stages of pregnancy than others. However, unborn babies are particularly sensitive to radiation during their early development, between weeks 2 and 15 of pregnancy. The health consequences can be severe, even at radiation doses too low to make the mother sick. Such consequences can include stunted growth, deformities, abnormal brain function, or cancer that may develop sometime later in life. However, since the baby is shielded by the mother's abdomen, it is protected in the womb from radioactive sources outside the mother's body. Consequently, the radiation dose to the unborn baby is lower than the dose to the mother for most radiation exposure events.

Pregnant women should consult with their physicians if they have any concern about radiation exposure to their unborn baby.

Additional information is available from the U.S. NRC in Regulatory Guide 8.13 – Instruction Concerning Prenatal Radiation Exposure, Revision 3 dated June 1999. A copy is available from:
<http://www.nrc.gov/reading-rm/doc-collections/reg-guides/occupational-health/active/8-13/>.

ATTACHMENTS

Attachment Description
Radioactive Shipment Notification Form
How Effective is a Syringe Shield
Tritium Handling Precautions
Radioactive Iodine Handling Precautions
Phosphorus-32 Handling Precautions
Technetium-99m Handling Precautions
MURR Reusable Shipping Containers
Radiation Safety Committee Enforcement Policy
Emergency Spill Procedures
Biological Effects of Radiation (U.S. NRC Fact Sheet)

RESEARCH SERVICE – RADIATION SAFETY MANUAL

Harry S. Truman Memorial Veterans' Hospital
Columbia, Missouri

Notification of Radioactive Material Shipment For Research Service (Please Type or Print Clearly)

Package Receipt Information

Requesting VA Authorized User's Name:		
Package Delivery Date:	Deliver to Room:	
Radionuclide Ordered:	Requested activity:	mCi
Shipping Vendor:		
Contact Person:	Phone No:	

*Federal Express and UPS deliver between 0900 to 1030 Monday – Friday. When purchasing radionuclides with University Funds, make sure the "Ship to" address is **Warehouse – Radiation Safety, VA Hospital, 800 Hospital Dr., Columbia, MO 65201.***

**You can deliver this notice to B050 or email it to the Radiation Safety Office:
Mary.Aldrich-Sarafianos@va.gov and Richard.Poelling@va.gov**

Radionuclide Transfers: (Radioactive Material Leaving the VA Hospital)

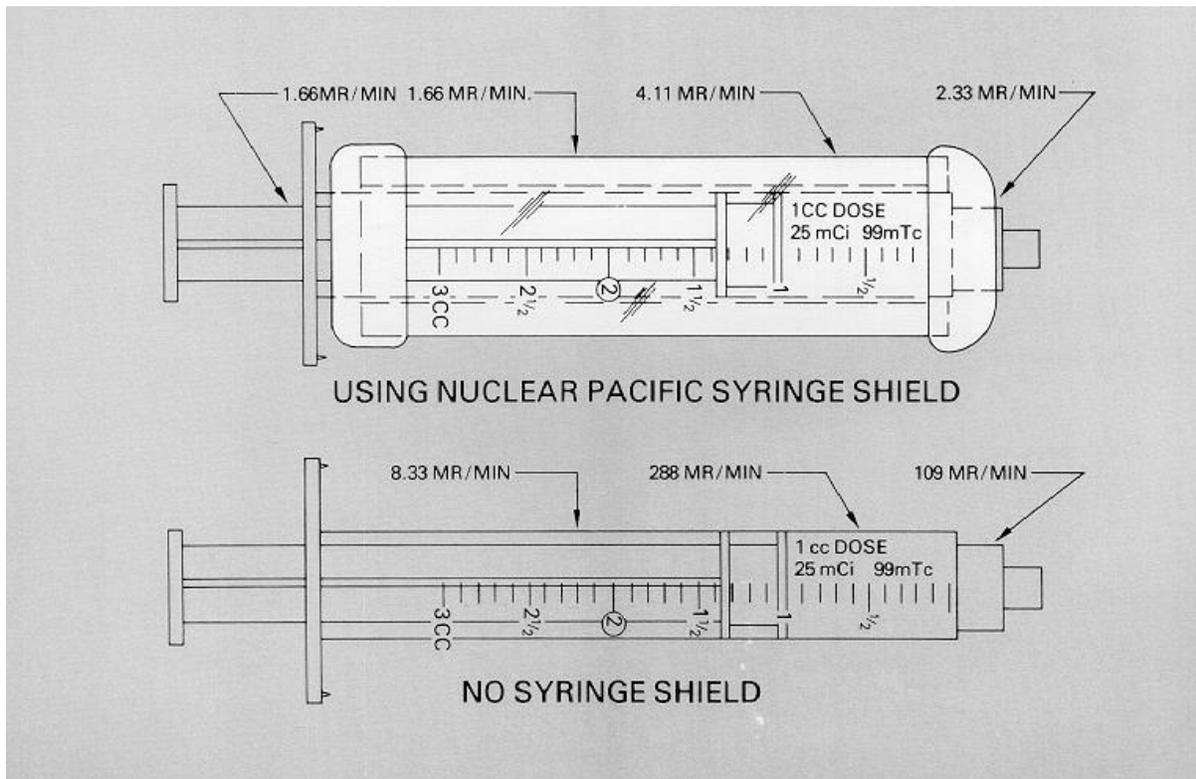
Requested transfer date:	Time:	
Radionuclide:	Activity:	mCi
Receiving authorized user / institution:		
Contact Person:	Phone No:	

All transfers of radioactive material leaving the VA hospital must be coordinated and approved by the Radiation Safety Office.

For RSO use only:

Request is within authorized users limits: Yes [] No []	
RSO Approval:	Date:
Special Instructions:	
Deliver shipment to lab:	

How Effective is a Syringe Shield?



A syringe containing 25 mCi of Tc-99m in a 1 milliliter volume has an exposure rate of 288 mR per minute unshielded or 4 mR per minute when a leaded glass syringe shield is utilized.

Acrylic syringe shields will also lower hand dose when working with high-energy beta emitters.

TRITIUM HANDLING PRECAUTIONS

Physical Data

Maximum Beta Energy = 0.019 MeV (100%)
Maximum Range of Beta in Air = about 4.7 mm
Physical Half-life = 12.3 years

Dosimetry

Millicurie quantities of tritium do not present an external exposure hazard because the low energy betas emitted cannot penetrate the outer dead layer of skin. The critical organ for tritium uptake is the whole body water. Three to four hours after intake, tritiated water is uniformly distributed in all body water. On average, tritiated water is eliminated with a ten-day biological half-life. Elimination rates may be increased by increasing water intake.

Precautions

1. Designate area for handling H-3 and clearly label all containers.
2. Prohibit smoking, eating, and drinking in the room where H-3 is handled.
3. Confine contamination by using transfer pipets, spill trays, and absorbent coverings.
4. Handle potentially volatile compounds in ventilated enclosures.
5. If enhanced containment is necessary, handle volatile compounds in closed systems vented through suitable traps.
6. Wear lab coat and disposable gloves at all times while working with radioactive material. Select gloves appropriate for chemicals handled.
7. Submit periodic urine samples for bioassay to determine uptake when large activities of H-3 are used.
8. Isolate, label, and dispose of wastes according to approved guidelines. Ask RSO for details.
9. On completing an operation, secure all H-3, remove protective clothing, monitor and decontaminate self and surfaces and wash hands.

Many tritium compounds readily penetrate gloves and skin. Handle these compounds remotely, wear two pairs of gloves and change the outer layer every twenty minutes. Tritiated DNA precursors are considered more toxic than tritiated water. However, they are generally less volatile and do not normally present a significantly greater hazard.

RADIOACTIVE IODINE HANDLING PRECAUTIONS

Physical Data

Principle Radiation Emissions:

Gamma	0.035 MeV (6.5%)
K α x-rays	0.027 MeV (112%)
K β x-rays	0.031 MeV (25.4%)

Unshielded Exposure Rate at 1 cm from 1 mCi Point Source = 1.4 R/hr.

Half-Value-Layer for lead shielding = 0.02 mm

Physical Half-life = 60.2 days

Dosimetry

The thyroid is the critical organ for I-125 uptake. Individual uptake and metabolism vary over a wide range. The thyroid may be assumed to accumulate 30% of soluble radioiodine uptake to the body and retain iodine with a 138 day biological half-life. All radioiodine in the body can be assumed to be eliminated via the urine.

The following radiological safety procedures must be adhered to during iodination labeling procedures:

Pre-iodination Considerations

1. All individuals performing iodinations must be approved by the Radiation Safety Committee to use radioactive material at this VA hospital.
2. All individuals performing iodinations must be observed by the Radiation Safety Officer (RSO) or his/her designate during initial iodination. (Iodinators may have to perform "cold" trial runs successfully prior to initial iodination, if deemed appropriate by the RSO).
3. All iodinators must schedule and receive a baseline thyroid bioassay prior to initial iodination.
4. All iodinations must be performed in an approved exhaust hood with a functioning face velocity of 100 fpm. Only the RSO can approve and exhaust hood for iodinations.
5. All iodinations should be performed using a "closed system" set-up. The unused iodine stock solution and iodination waste must be stored in an approved location.

Considerations During Iodinations

1. All iodinators must wear gloves, a lab coat and the appropriate dosimetry (whole body + TLD ring) when performing iodinations. Two layers of disposable gloves are recommended. Hands should be monitored frequently and contaminated gloves should be removed and discarded in the appropriate waste container.
2. All waste containers used in the procedures should contain either something to prevent volatility (i.e., charcoal, sodium thiosulfate, sodium hydroxide, etc).
3. In case of an emergency or if inhalation or skin absorption is suspected, the RSO is to be contacted immediately. All iodinators must be well versed in emergency procedures and have on hand supplies to absorb any potential spill.

Post-Iodination Considerations

1. All iodimators must perform a contamination survey immediately after completing each iodination. Records of contamination results must be kept in a log book for review by the RSO. Contamination records must be kept for 3 years.
2. At a minimum, contamination surveys should include the exhaust hood ledge, floor and bench top of the surrounding area.
3. All iodimators must monitor their hands, feet and body prior to leaving the iodination facility. If contamination is present, the iodinator should contact the RSO immediately.
4. Each individual handling Iodine-125 or 131 labeled materials in an unsealed form and using an activity greater than or equal to 1.0 mCi must undergo a thyroid bioassay within 72 hours.

PHOSPHORUS-32 HANDLING PRECAUTIONS

Physical Data

Maximum Beta Energy = 1.71 MeV (100%)
Maximum Range of Beta in Air = about 6 meters
Maximum Range of Beta in Water = about 8 mm
Physical Half-life = 14.3 days

Dosimetry

The bone is the critical organ for intake of transportable compounds of P-32. Phosphorus metabolism is complex; 30% is rapidly eliminated from the body, 40% possesses a 19-day biological half-life, and the remaining 30% are reduced by radioactive decay. The lung and lower large intestine are the critical organs for inhalation and ingestion, respectively, of non-transportable P-32 compounds.

The high-energy beta emissions can present a substantial skin dose hazard. Multi 100-millicurie (3.7 GBq) quantities of P-32 can produce significant secondary radiation presenting an external exposure hazard

The dose rate at the mouth of an open vial containing 1 mCi of P-32 in 1 ml of liquid is roughly 26 rem/hour. Since this dose rate will not be attenuated significantly by air, shielding materials should be placed between the source and personnel to absorb most of the radiation. The best shield for a P-32 source is a material like Lucite 1.3 cm (1/2 inch) thick or other plastic, which will absorb the beta particles while generating little secondary radiation. For mCi amounts of P-32, thin, high density shielding such as lead 3 to 6 mm thick should be added to the exterior of the Lucite shield to absorb the higher intensity secondary radiation.

A high local dose can be received if the radioactive material is touched and allowed to remain on the skin or gloves. Both the hands and the face can receive a considerable dose of radiation near an open container of P-32, particularly if the radioactivity is in a concentrated form. Therefore, never work over an open container of P-32.

Precautions

1. Designate area for handling P-32 and clearly label all containers.
2. Store P-32 behind Lucite and/or lead shielding.
3. Wear extremity and whole body dosimeters while handling mCi quantities.
4. Handle millicurie quantities of P-32 behind 1.3 cm thick Lucite shielding. Where necessary, increase shielding by attaching 3 to 6 mm thick lead sheets to the outside of the Lucite to reduce secondary radiation
5. Do not work over open containers.
6. Practice routine operations to improve dexterity and speed before using P-32.
7. Avoid skin exposure by using tools to indirectly handle unshielded sources and potentially contaminated vessels.
8. Use transfer pipettes; spill trays and absorbent coverings to confine contamination.
9. Handle potentially volatile chemical forms in ventilated enclosures (fume hoods).

10. Use lab coat and disposable gloves for secondary protection.
11. Regularly monitor and promptly decontaminate gloves and surfaces to maintain contamination and exposure control.
12. Use end window or pancake Geiger-Mueller detector or liquid scintillation counter to detect P-32.
13. Isolate waste in clearly labeled shielded container and hold for pickup by the Radiation Safety Staff.
14. On completing an operation, secure all P-32, remove protective clothing, monitor and decontaminate self and surfaces if necessary.

TECHNETIUM – 99M HANDLING PRECAUTIONS

Physical Data

Radiation:	Gamma: 141 keV (89% abundance) X-rays: 18 keV (6% abundance), 21 keV (1.2% abundance)
Gamma Constant:	0.77 R/hr at 1 cm from an unshielded 1 mCi point source
Half-Life [T1/2]:	Physical t1/2: 6.0 hours Biological T1/2: approximately 1 day Effective T1/2: approximately 4.8 hours
Specific Activity:	5.27E6 Ci/g [1.95E17 Bq/g]

Radiological Data

Radiotoxicity:	0.063 mrem/mCi [1.7E-11 Sv/Bq] of Tc-99m ingested [CEDE] 0.027 mrem/mCi [7.21E-11 Sv/Bq] of Tc-99m inhaled [CEDE]
Critical Organ:	Thyroid Gland; Upper GI Tract
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption.
Radiological Hazard:	External & Internal Exposure; Contamination.

Shielding

Lead (Pb):	< 1 mm [Half Value Layer] 1 mm [Tenth Value Layer]
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Dosimetry Monitoring

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

Detection & Measurement

Portable Survey Meters: Geiger-Mueller to assess shielding effectiveness

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

Special Precautions

- Store Tc-99m behind 1/4 –inch thick lead shielding
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact.
- Ensure that an appropriate, operational survey meter is present in the work area and turned on whenever Tc-99m is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed.
- Shield waste containers as needed to maintain accessible dose rate ALARA and < 2 mR/hr.

Radiation Safety Committee Enforcement Policy

The Radiation Safety Committee (RSC) is responsible for approving authorized users of radioactive material and keeping the hospital in compliance with all U.S. Nuclear Regulatory Commission regulations and Veterans Health Administration (VHA) directives. The day-to-day operation of the radiation safety program is the responsibility of the Hospital's Radiation Safety Officer (RSO). The RSO conducts quarterly audits of all areas (Research, Nuclear Medicine) that either possess and/or use radioactive material during the previous 3 months. The audits document that the authorized user's radiation safety program is being conducted in compliance with the Hospital's Master Material License and commitments granted by the U.S. Nuclear Regulatory Commission

Audit Objectives:

- To determine if licensed activities are being conducted in a manner that will protect the health and safety of workers and the general public.
- To determine if the authorized user's (AU) program is being conducted in accordance with the authorized users radioactive material permit and the departments policies and procedures manual.

Focus Areas:

The inspection/audit will be conducted in a manner that will develop conclusions about the AU's performance relative to the following focus areas:

- Security and control of licensed material so as to limit radiation exposure to workers and members of the public to values below 10 CFR Part 20 limits.
- The AU maintains shielding of licensed materials in a manner consistent with operating procedures and design and performance criteria for devices and equipment.
- The AU should implement comprehensive safety measures to limit other hazards from compromising the safe use and storage of licensed material.
- The AU supports the hospital's radiation dosimetry program to accurately measure and record radiation doses received by workers or members of the public as a result of licensed operations.
- The AU provides radiation instrumentation in sufficient number, condition, and location to accurately monitor radiation levels in areas where licensed material is used and stored.
- The AU should ensure that workers are knowledgeable of radiation uses and safety practices, skilled in radiation safety practices under normal and accident conditions, and, empowered to implement the radiation safety program.

Focus areas are structured as a performance expectation and address the program areas most commonly associated with measures that prevent overexposures, medical events, or release, loss or unauthorized use of radioactive material.

In reviewing the AU's performance, the RSO should cover the period from the last to current inspection. However, older issues preceding the last audit should be reviewed, if warranted by circumstances, such as incidents, noncompliance, or high radiation exposures.

Deficiency Levels:

An escalated enforcement format is based on the fact that there are items, which are of more importance than others, based upon the repercussions which could result from noncompliance. While all deficiencies can lead to violations imposed by the NRC, the tiered enforcement reflects the level of hazard and the level of corrective action necessary. A four tiered enforcement strategy is proposed.

CLASS OF DEFICIENCY
Level 1 SERIOUS
Level 2 MAJOR
Level 3 MINOR
Level 4 CONCERN

Level 1 - SERIOUS DEFICIENCIES are the most serious from the potential damage or injury to the environment, the radiation workers, the general public and may require immediate reporting to the U.S. Nuclear Regulatory Commission.

Level 2 - MAJOR DEFICIENCIES are those, which if continued, could result in the NRC issuing a notice of violation. This level of deficiency would require immediate corrective action by the authorized user.

Level 3 - MINOR DEFICIENCIES are associated with the focus areas of the authorized user's radiation safety program.

Level 4 - CONCERN DEFICIENCIES are those of an administrative, documentation or record keeping type. As this level of deficiency is minor, they can usually be corrected immediately on the spot.

Authorized User's Response to Deficiencies:

- **Level 1 - SERIOUS DEFICIENCIES** - The AU will be told immediately of the deficiency by the RSO and the operation will be immediately curtailed. The incident will be reported to the RSC chairman and/or the Hospital Director. The potential health and safety, and regulatory implications will govern the remedial actions required. Potentially, the AU's authorization may be immediately suspended. Reactivation of the authorization will not occur until a RSC review has been conducted. The AU will be required at a minimum to report to the RSC what occurred, why it occurred and how the AU intends to prevent a recurrence and ensure safe continuation of the authorization.
- **Level 2 - MAJOR DEFICIENCIES** - The AU will be told of the deficiency immediately by the RSO. The AU will be required to take corrective actions in a time period established to correct the deficiency. The corrective action will require a written response from the AU to the RSO as to what the deficiency was, why the deficiency occurred, and the remedial action that the AU has taken to assure that it will not recur in the future. The report will be forwarded to the RSC for their consideration along with recommendations of the RSO.

- **Level 3 - MINOR DEFICIENCIES** - The AU will be informed of the deficiency in the audit report. The AU will be required to take corrective action within a given time period to correct the deficiency. The RSO will follow up to verify the corrective actions have been completed and report the findings to the RSC at the next regularly scheduled meeting.
- **Level 4 - CONCERN DEFICIENCIES** - The AU will be informed of the deficiency in the inspection report. The RSO may discuss corrective measures at the time of the audit. The AU will insure that the deficiency has been corrected in a timely fashion and typically review of the correction will occur at the next inspection.

Non-Cited Deficiencies:

Authorized Users and radiation workers are responsible to ensure NRC regulations are observed. The RSO expects the AU or their staff to self-identify and correct noted deficiencies in a timely manner. To encourage this practice, the RSO will not cite a deficiency if the AU self identifies a problem and immediately takes corrective action. The deficiency and corrective action taken must be reported to the RSO. Deficiencies noted during an audit or inspection will be documented and cited in accordance with this enforcement policy.

Deficiency Level Examples and Required Response:

The following table provides examples of each deficiency level, the required corrective action by the authorized user and the follow-up action by the Radiation Safety Committee (RSC) and the Radiation Safety Officer (RSO).

DEFICIENCY LEVEL EXAMPLES AND REQUIRED RESPONSE

Deficiency Level	Type / Examples	Corrective Action By AU	RSO / RSC Follow-up Action
Level 1 SERIOUS	<p>Major loss of program control; e.g.,</p> <ul style="list-style-type: none"> - Lack of control of radioactive material, - Spread of contamination to unrestricted areas, - Any NRC reportable event, - Personnel exposure in excess of limit - Willfully providing false information or data to an inspector - Escalation of Level 2 	<p>Immediate cessation of operations</p> <ul style="list-style-type: none"> - AU must respond to RSO's findings in writing: - Reason for the violation, <u>or</u> - If contested, the basis for disputing the violation, - Corrective steps that have or will be taken to prevent reoccurrence, 	<p>RSO notifies the RSC chairman / Director:</p> <ul style="list-style-type: none"> - Notify VHA NHPP if required - The AU must report to the RSC - The RSC may suspend authorization for a specified period of time.
Level 2 MAJOR	<p>Major program violations: e.g.,</p> <ul style="list-style-type: none"> - Evidence of eating and/or drinking in restricted area, - Major contamination, - Spread of contamination, - Program violation due to inadequate personnel training, - No surveys performed for more than 3 months, - Security violation where access to radiological items or sources presents exposure risk to public >2 mR/hr. - Falsification of Records - Failure to provide complete information to inspector/auditor - Escalation of Level 3 	<p>AU must respond to RSO's findings with corrective actions in writing:</p> <ul style="list-style-type: none"> - Reason for the violation, or - If contested, the basis for disputing the violation, - Corrective steps that have or will be taken to prevent reoccurrence, - The date when full compliance will be achieved. 	<p>RSO notifies the RSC chairman</p> <ul style="list-style-type: none"> - RSC may temporarily suspend the AU's authorization or limit specific aspects of the approval.
Level 3 MINOR	<p>Minor program violations: e.g.,</p> <ul style="list-style-type: none"> - Improper waste storage or identification - Failure to perform prescribed area surveys - Minor contamination found during inspection which was unidentified by AU's surveys, - Improper ordering of radioactive material, - Failure to provide or use proper shielding to keep exposures ALARA, - Failure to institute corrective actions to prevent re-occurrence of previously identified problems, - Security violation where access to significant items presents exposure risk to public, but <2 mR/hr, - Escalation of Level 4 	<p>Immediate response to correct if possible; or correct deficiency within specified time frame</p>	<p>RSO verifies and documents corrective action.</p> <p>Deficiency reported to RSC at next regular meeting.</p>
Level 4 CONCERN	<p>Administrative; e.g.,</p> <ul style="list-style-type: none"> - Poor or incomplete record keeping of surveys, inventory, - Minor deficiencies immediately corrected, - Security violation, but no significant exposure risk to public, 	<p>AU will complete or correct deficiency</p>	<p>RSO verifies and documents corrective action during next audit.</p>

EMERGENCY SPILL PROCEDURES FOR RADIOACTIVE MATERIAL

MINOR SPILLS OF LIQUIDS AND SOLIDS

1. **NOTIFY** - Notify persons in the area that a spill has occurred.
2. **PREVENT THE SPREAD** - Cover the spill with absorbent paper.
3. **CLEAN UP** - Clean up the spill using disposable gloves and absorbent paper. Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Also put contaminated gloves and any other contaminated disposable material in the bag.
4. **SURVEY** - Survey the spill area with a low-range radiation detector survey meter. Also check your hands, clothing, and shoes for contamination.
5. **REPORT** - Report the incident to the Radiation Safety Officer and record the survey results.

MAJOR SPILLS OF LIQUIDS AND SOLIDS

1. **CLEAR THE AREA** - Notify all persons not involved in the spill to vacate the room.
2. **PREVENT THE SPREAD** - Cover the spill with absorbent paper or pads, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spread.
3. **SHIELD THE SOURCE** - If possible, the spill should be shielded, but only if it can be done without further contamination or significant increase in radiation exposure.
4. **CLOSE THE ROOM** - Leave the room and lock the door(s) to prevent entry.
5. **CALL FOR HELP** - Notify the Radiation Safety Officer immediately.
6. **PERSONNEL DECONTAMINATION** - Contaminated clothing should be removed and stored for further evaluation by the RSO. If the spill is on the skin, flush thoroughly and then wash with mild soap and lukewarm water.
7. **CLEAN UP** - The Radiation Safety Officer will supervise the cleanup of the spill. Notify the person responsible for the laboratory:

Authorized User _____

Office Phone _____ Home _____

EMERGENCY SPILL PROCEDURES FOR RADIOACTIVE MATERIAL

INCIDENTS INVOLVING RADIOACTIVE DUSTS, MISTS, FUMES, ORGANIC VAPORS, AND GASES

1. **CLEAR THE AREA** - Notify all personnel to vacate the room immediately.
2. **PREVENT THE SPREAD** - Shut down ventilation system, if possible, unless it is determined that the room ventilation system needs to be used to clear the air for access purposes.
3. **CLOSE THE ROOM** - Vacate the room. Seal the area, if possible. Ensure that all access doors to the area are closed and posted with radiation warning signs, or post guards (trained) at all access doors to prevent accidental opening of the doors or entry to the area.
4. **CALL FOR HELP** - Notify the RSO immediately.
5. **PERSONNEL DECONTAMINATION** - Survey all persons who could have possibly been contaminated. Decontaminate as directed by the RSO. Promptly report suspected inhalations and ingestion of licensed material to the RSO.
6. **CLEAN UP** - Decontaminate the area only when advised and/or supervised by the RSO. Allow no one to return to work in the area unless approved by the RSO.
7. **COOPERATE** - Cooperate with the RSO and/or the RSO's staff (e.g. investigation of root cause, provision of requested bioassay samples) Follow the instructions of the RSO (e.g., decontamination techniques, surveys, provision and collection of bioassay samples, requested documentation).

MINOR FIRES IN RESTRICTED AREAS

1. **RESCUE** - Rescue any person in immediate danger. Notify all persons present to vacate the area.
2. **ALARM** - Pull the fire alarm box and call the operator at 3333 to report the fire. Then notify the RSO if radioactive material is utilized in the area.
3. **CONFINE** - Confine the fire by closing all doors.

4. **EVACUATE / EXTINGUISH** - Know the location of fire exits and extinguishers. Only attempt to extinguish a fire, if it is clearly manageable.

5. **CLEAN UP** - Once the fire is out, isolate the area to prevent the spread of possible radioactive contamination. Survey all persons involved in combating the fire for possible contamination. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water, then washing with a mild soap. Allow no one to return to work in the area unless approved by the RSO.

U. S. Nuclear Regulatory Commission
Fact Sheet

Biological Effects of Radiation