**Montana State University – Bozeman**

**Radiation Safety Manual**

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**Radiation Safety Program: Purpose, Scope and Responsibilities**

**Purpose**

The purpose of this radiation safety manual is to define policies and procedures pertaining to the use of radiological materials and devices in research at Montana State University (MSU). These policies and procedures are designed to safeguard personnel and the environment from radiologically hazards without limiting research.

The work practices, procedures, and policies specified in this manual are based on regulatory requirements and accepted radiation safety practices. Implementation of these measures will reduce the likelihood that an incident involving radiological hazards will occur and will fulfill regulatory radiation safety requirements.

Laboratory work can involve potential exposure to radiological hazards, as well as to chemical and biological hazards. Consequently, this manual should be used in conjunction with the MSU Chemical

Safety Manual and Biological Safety Manual.

For information about specific radiological safety for operations not covered in this manual, contact the Radiation Safety Officer (RSO) at 994-7317.

**Scope**

MSU holds a broad scope type A license which is a specific license authorizing receipt, acquisition, ownership, possession, use, and transfer of any chemical or physical form of the byproduct material specified in the license, but not exceeding quantities specified in the license, for purposes authorized by the Nuclear Regulatory Commission (NRC).

This manual applies to all MSU research activities involving radiological materials or devices. All faculty, staff, students, and visitors who work on MSU sponsored projects or at MSU facilities are included in the scope of this manual.

Radiological hazards include all materials or devices capable of producing ionizing radiation. This includes, but is not limited to: open source radioactive materials, sealed source radioactive materials, nuclear gauges and x-ray producing devices. *For x-ray producing devices refer to the x-ray safety manual.*

**Radiological Safety Program Goals**

The Radiation Safety Program is designed to provide guidance on the safe handling of ionizing radiation, minimization of risks of research use, keeping exposure to personnel as Low As Reasonably Achievable (ALARA), and maintaining compliance with all regulations pertaining to radiological hazards.

The mission of the Radiation Safety Program at MSU is to ensure a safe environment for individuals working with ionizing radiation and to ensure the protection of the community and environment by keeping exposure to radiation ALARA. To accomplish this, the Radiation Safety Program provides technical advice to Principal Investigators (PIs) on laboratory containment, security, and safety procedures. Other aspects of the Radiation Safety Program include developing emergency response plans for handling spills and personnel containment, overseeing laboratory inspections to ensure safe laboratory standards are maintained, and providing radiation safety training.

**Roles and Responsibilities**

Success of the Radiation Safety Program requires a team effort involving the Radiation Safety Committee (RSC), PIs, laboratory workers, the Occupational Health Program (OHP), and Safety and Risk Management (SRM). PIs are responsible for the health and safety of personnel who work under their supervision and occupy their laboratory space. MSU administration and the RSC endorses this manual and encourage active participation in maintaining high standards at MSU.

Organizational Chart for the Administration of NRC License #25-00326-06

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**Director of Research Compliance (IO)**

The IO has overall responsibility for:

* Oversight for the control of ionizing radiation in research laboratories and for ensuring that a comprehensive Radiation Safety program is in place for the safe handling of all radioactive materials.
* Direct functional responsibility for the RSC and Radiation Safety Program.
* Develops and ensures communication between the RSC and other research related committees.
* In consultation with RSC, appoints committee members to the RSC.

**Radiation Safety Committee (RSC)**

The RSC is responsible for reviewing and approving practices and protocols involving the use of ionizing radiation in all research activities at MSU. The RSC carries out these functions pursuant to requirements set forth by the Nuclear Regulatory Commission (NRC), the State of Montana, and Occupational Safety and Health Administration (OSHA).

The RSC’s responsibilities include:

* Overall oversight of the Radiation Safety Program at MSU, including development of new, and review of existing, policies and procedures designed to enhance the Radiation Safety Program.
* Reviews and approves training programs.
* Coordinates the radiological safety requirements with other campus‐wide committees (e.g., IACUC) or programs (e.g., Occupational Health Program).
* Reviews and approves new research protocols involving ionizing radiation in accordance with guidelines established by regulatory agencies and MSU as well as maintains protocol approval and review of modifications.
* Investigates violations of Radiation Safety procedures or policies and significant accidents or exposures involving radiological materials or devices.
* If appropriate, recommends disciplinary action to the proper MSU officials.

**Radiation Safety Officer (RSO)**

The RSO is responsible for developing, leading, directing, and managing a comprehensive Radiation Safety program for MSU. The Radiation Safety program must meet NRC, OSHA, any other granting agency, Federal, State, and local requirements. The program includes close cooperation and interaction with committees approving research protocols and procedures for use of human subjects (Institutional Review Board (IRB)), Institutional Animal Care and Use Committee (IACUC), and Institutional Biosafety Committee (IBC). The RSO will provide guidance and consultation to assess the risk of working with ionizing radiation. The RSO interacts with the research, teaching, and diagnostic community to inform and ensure compliance with State and Federal reporting or audit requirements, and to inspect and correct deficiencies when noted.

The RSO duties include:

* The inspection of the physical facilities and equipment for compliance with general regulatory guidelines for research and diagnostic work using radioactive materials in accordance with developed laboratory inspection checklists.
* Review of laboratory radiation safety manuals and standard operating procedures (SOPs) for compliance with regulatory guidelines.
* Provides general guidance about health and safety standards, and provides the Radiation Safety review for all research proposals presented to the RSC.
* Helps to ensure that radioactive wastes are properly handled, transported, and disposed of outside of laboratory facilities and after leaving the laboratory buildings per applicable state and federal regulations.
* Maintains list of approved radiation safety laboratories with inspection dates and results.
* Responsible for assisting the PI to develop appropriate lab‐specific radiation safety manuals for all activities using radioactive materials.
* The RSO regularly reports on the radiation safety program to the RSC. The RSO’s report should include routine operational updates and any significant problems or violations of the regulatory mandates or RSC requirements on any research‐related incidents that have occurred.
* Manage a personnel monitoring program for personnel expected to receive 10% of their annual exposure limits
* Manage an exposure and contamination survey program in accordance with NRC regulations management
* Maintain a sealed source inventory and conduct sealed source leak tests
* Provide training to all MSU personnel
* Conduct instrument calibrations
* Ensure that security and other regulatory requirements are met
* Perform license communications with the NRC

**Principal Investigators (PI)**

Principal investigators are responsible for the health and safety of all personnel and compliance with all applicable regulations and the criteria established in this manual in their laboratories.

The PI:

* Notifies the RSC and obtains prior RSC approval for work involving radioactive material and conforms to all terms and conditions of RSC approval. Ensures that all laboratory personnel are adequately trained in the practices and techniques required to ensure safety and the procedures for dealing with accidents.
* Ensures that individuals working in the facility are experienced and proficient in handling radiological materials or devices.
* Makes available to all laboratory personnel the protocols that describes the hazards and the precautions to be taken.
* Ensures that the required safety practices, techniques, engineering controls and PPE are provided and employed.
* Ensures that laboratory hazards are effectively communicated to laboratory personnel and controls are in place to minimize risks associated with these hazards.
* Notifies the RSO of any spills or incidents involving radiological materials or devices that result in exposure to laboratory personnel or the public, or release to the environment.
* Ensures that radiological materials are disposed of according to regulations, as outlined in this manual.
* Ensures that radiological materials to be transported are packaged and shipped in accordance with regulations and per this manual.

**Occupational Health Program**

The Occupational Health Program (OHP) is primarily responsible for establishing and performing appropriate medical surveillance for all personnel performing research or supporting research such as animal care workers, facilities, Police and Public Safety. Surveillance may be required at the time of hire or transfer into the research environment and periodically depending on the work environment, occupational exposure and risk for each position or job category. OHP is responsible for reporting all radiological exposure incidents to the appropriate personnel.

In addition to performing medical surveillance, OHP is also responsible for:

* Coordinates with Montana Occupational Health to provide medical evaluations and surveillance program for personnel working in the facility.
* Files Workman’s Compensation reports.

**Laboratory Workers**

Laboratory workers are the most important element in developing and maintaining a safe laboratory environment. Laboratory workers are responsible for their own health and safety, as well as that of their coworkers. An incident caused by one laboratory worker can have a widespread effect on others.

Laboratory workers are expected to:

* Participates in and completes all required training to ensure that they are adequately trained.
* Fully understands the radiological materials or devices and procedures used in the laboratory and the risks associated with exposure.
* Follows all laboratory practices, protocols and complies with all applicable policies, procedures, and guidelines.
* Informs the PI and RSO of any potential problems with the operating procedures or equipment which may result in the creation of a potential hazard.
* Completes any necessary medical surveillance.
* Reports thefts, security incidents, accidents, spills, or contamination incidents to PI and RSO.

**Approval of Research Projects**

**Who Needs Approval**

The RSC reviews and approves all activities in which ionizing radiation is produced which may include research, teaching, and diagnostic activities. Activities that are capable of producing ionizing radiation include, but not limited to, all of the categories below:

* Use of open source radioactive materials such as 3H, 32P and 14C
* Use of sealed radioactive sources such as 63Ni, 57Co and nuclear density gauges
* Use of devices that are capable of producing X-rays such as X-ray diffraction units, X-ray imaging units and electron microscopes

**Principles which Govern the RSC**

The RSC operates upon the following regulations/guidelines:

* 10 CFR NRC Regulations for use of nuclear materials
* 49 CFR DOT Hazardous Materials Regulations
* Montana Code Title 50 Chapter 79: Nuclear Regulation
* Montana State University Radiation Program Guidelines

The planning and implementation of safety protocols to prevent workplace exposure to ionizing radiation and to eliminate the spread of contamination must be part of every laboratory’s routine activities and radiation safety manual. No work should be considered so important that it jeopardizes the well‐being of the worker or the environment. The handling of radiological agents and devices capable of producing ionizing radiation requires the use of precautionary measures dependent on the agents involved and the procedures performed. It is the purpose of this manual to provide background information and guidelines to be used in conjunction with other resources for the evaluation, containment, and control of radiological hazardous materials and ionizing radiation at MSU.

**RSC protocol**

A PI applying for RSC approval for research, teaching, or diagnostic activities needs to submit a completed RSC protocol. In order for the application to be processed, it must be signed (*electronically accepted*) by the PI and any supplemental materials must be included. A PI applying for approval of teaching activities involving potential ionizing radiation hazards must contact the RSO. The RSO will assist the PI in developing appropriate radiation safety training for students. The PI is responsible for ensuring that all students are all trained prior to working with ionizing radiation. The RSO will act as a resource to assist the PI in developing a radiation safety protocol and performing a facility review.

**Requests for modifications in activities after approval**

All modifications to currently approved research and diagnostics activities are required to have RSC review and approval prior to implementation. Minor changes that do not increase the risk to workers, the community, and/or the environment may be processed as an administrative approval performed by the RSC Chair and/or RSO. Examples of significant modifications may include; the addition of potentially radiological hazardous materials, and the addition of materials or procedures that may increase the risks of the research. Administrative modifications may be approved by the RSC Chair or the RSO. Examples of administrative modifications may include the addition/removal of personnel, and removal of isotopes and locations. The RSC modification approval is valid until the end of the original approval period (5 years).

**Reports of unexpected adverse events**

All unanticipated/adverse events should be reported to the RSO and RSC chair in writing as well as any

actions taken on the part of the researcher as a response to the adverse event. NRC regulations have established reporting requirements depending on the incident (<http://www.nrc.gov/about-nrc/emerg-preparedness/faq/reporting-requirements.html>).

**Notification**

Prior to the expiration of an approved protocol, the PI will receive an e‐mail notification that their approved protocol is about to expire. PIs desiring to continue their research are responsible for

completing a new RSC protocol and returning it to the RSO in time for review before the

expiration date. If the PI fails to submit a new protocol and gain RSC approval prior to the expiration data, all work on the project must be discontinued.

**Renewals**

A renewal notice serves as a mechanism for the PI to provide periodic updates of the research occurring

under an RSC protocol and this form is sent to the PI listed on the original approval after initial approval of a protocol. The PI is asked to list any proposed deviations from the protocol as initially approved (or since the last renewal notice); changes in laboratory staff working on the project; if there have been any problems/adverse events; and to provide a summary of the project. If there are significant deviations from the protocol the PI will need to submit a modification or in some cases may need to submit a new RSC protocol to cover the additional experiments. With proper attention to amendment procedures, this situation will be prevented.

**Regulations and Guidelines**

The following is a summary of federal, state, local agency and MSU regulations and guidelines that either regulate or provide guidelines covering the use of ionizing radiation:

* NRC regulations on the use of nuclear materials are listed under Title 10 of the code of Federal regulations. These are binding regulations to our nuclear materials license issued by the NRC. <http://www.nrc.gov/reading-rm/doc-collections/cfr/>
* NRC NUREG-1556 provides consolidated guidance about materials licenses including program-specific guidance for MSU’s broad scope license. Where appropriate, this series of documents has been used to establish guidelines for MSU’s radiation safety program. <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1556/>
* Occupational Safety and Health Administration has established standards for employees under the title of Ionizing radiation These regulation covers occupational exposure to ionizing radiation. OSHA specifies a combination of engineering controls, work practices, and training to reduce the risks from ionizing radiation.

<https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10098>

* U.S. Department of Transportation and the International Air Transportation Authority: These organizations have strict requirements governing the shipment and transportation of hazardous materials, including radiological materials. Chapter 11 provides information on shipping regulations.

<http://www.ecfr.gov/cgi-bin/text-idx?SID=1d49a3b137cb1b6fc45251074e634b44&tpl=/ecfrbrowse/Title49/49tab_02.tpl>

* The MSU Radiation Safety Committee has documented policies and procedures into this document as requirements and/or have included these as appendices to this document.

**Ionizing Radiation and Safety Principles**

**Sources of Ionizing Radiation**

We are exposed to ionizing radiation constantly, also known as background radiation. The sources of our background radiation exposure ranges from photons from the sun to radon in our homes. In the research and teaching environment here at MSU additional sources can be found. Examples of these sources are:

* Open source radiochemicals (Examples: liquids containing 3H, solids containing 14C)
* Sealed sources (Examples: 63Ni ECD devices, nuclear density gauges and Mossbauer sources)
* X-ray imaging and cabinet X-ray devices
* X-ray diffraction and fluorescence machines
* Electron microscopes

**Types of Radiation**

Ionizing radiation is considered to be any emission with enough energy to ionize an atom or molecule. The types of emissions that are capable of this are:

* Alpha
* Beta
* X-ray
* Gamma
* Neutron

**Units of Radioactivity**

Radioactivity: A unit that measures the number of emissions capable of ionization materials per unit time. Radioactivity can be measure in Curies (Ci) or Becquerel (Bq).

Dose or Exposure: A measure of the health effects to the human body from ionizing radiation. Dose or Exposure can be measured in Roentgen Equivalent Man (Rem) or Sievert (Sv).

Dose or Exposure Rate: A measure of the rate in which health effects from ionizing radiation are being accumulated at a particular location. Dose or Exposure rates can be measured in Rem/hr or Sv/hr.

**Protection from Ionizing Radiation**

The Radiation Safety Program is designed to keep dose or exposure to personnel *As Low As Reasonably Achievable.* The principles of radiation safety protection are:

* Time – Minimizing time in a radiation field
* Distance – Maximizing the distance from a source of ionizing radiation
* Shielding – Use or appropriate shielding to minimize exposure rates at a location

**Types of Users and Training Plan**

**Types of Users**

Montana State University’s (MSU’s) Office of Research Compliance (ORC), specifically through the Radiation Safety Officer (RSO), is responsible for ensuring that radiation safety training is provided to all MSU employees who work with radioactive materials (RAM) or equipment containing sealed sources. Training must be completed prior to beginning work with radioactive materials or equipment containing sealed sources. Instructions on the hazards present will be provided to employees whose duties require them to work in the same room but do not directly work with RAM. Thus required instructions and/or training is dependent on the job functions performed and falls into three categories:

* Open Source RAM Laboratory Workers
* Users of Equipment Containing Sealed Sources
* Ancillary RAM Workers

Training will include general radiation safety, MSU specific standard operating procedures, and regulatory-required content based on the job function. Additional educational topics identified by the specific department in which you work or after consultation with the RSO may be covered in the training as well.

***All successful training completions shall be documented and retained by the ORC prior to starting any work with or near radioactive materials or machines producing radiation. Failure to do so will be considered a violation of MSU’s radiation safety policy.***

**Training Plan**

**OPEN SOURCE RAM LABORATORY WORKERS**

***Training Content***

Training for laboratory workers with direct use of open source radioactive materials and PI’s overseeing this type of work will include the following topics *per NRC regulations 10 CFR Parts 19, 20*:

* Applicable regulations
* Atomic structure
* Alpha, beta, and gamma radiation
* Radioactivity units
* Radioactive decay
* Background radiation
* Steps to minimize exposure (ALARA)
* Radiation protection principles
* Radiation surveys
* Radiation inventory
* Recordkeeping
* Personal protective equipment (PPE)
* Waste disposal
* Policy on transporting radioactive material
* Occupational dose limits and proper use of dosimetry
* Policy on radiation and pregnancy
* Purchase, receipt, and storage of radioactive material
* Radiation instrumentation
* Spill and contamination procedure (non-emergency)
* Emergency response

***Additional Training Components as Needed***

* HAZMAT – Packaging, Shipping and Transportation

***How Do I Get Training?***

Training courses and instructions for accessing them are listed on the training page of the ORC website:

<http://www.montana.edu/orc/radiation/training.html>

* Initial training for RAM laboratory workers and PI’s supervising radiation work is covered in the Radiation Safety for Laboratory Research Personnel course, which is offered quarterly. This training course includes hands on training and an assessment exam upon completion. This course is presented by the RSO.
* If you must use radioisotopes before attending a quarterly laboratory safety course, you may request a personal training session from the RSO.

***Retraining Frequency***

Full training for open source laboratory RAM workers is required every three years, with two refresher trainings required between full trainings (approximately annually). In order to satisfy this requirement, you can:

* Take an open source RAM laboratory worker refresher training course online through the *Radiation Safety Program* course housed on D2L, or
* You can request an in-service presentation for a laboratory: The same general material will be presented as in the refresher course but can be streamlined to fit the needs of the group; where more hands-on practice time with survey meters and calculating efficiencies of liquid scintillation counters and dpm can be addressed in greater detail.
* Full training can be requested by contacting the RSO at any time.

**USERS OF EQUIPMENT CONTAINING SEALED SOURCES**

***Training Content***

Training for operators of equipment containing sealed sources (Examples: 63Ni, 57Co, 137Cs, 241Am) will include only pertinent topics relative to their specific job function and can include:

* Applicable regulations
* Operator responsibilities
* Potential radiation hazards in work areas
* Steps to minimize exposure (ALARA)
* Operator safety
* Basic radiation biology
* Risk estimates, including caparison with other health risk
* Radiation effects on skin
* Policy on radiation and pregnancy
* Recording of beam usage time
* Reporting high or accidental exposures
* Occupational dose limits and proper use of dosimetry
* Department-specific work rules
* Policy on transporting radiation producing machines
* Procedure risks

***Additional Training Components as Needed***

* Nuclear gauge training
* HAZMAT – Packaging, Shipping and Transportation
* Security training *per* *NRC regulations under 10 CFR Part 37*

***How Do I Get Training?***

Training courses and instructions for accessing them are listed on the training page of the ORC website:

<http://www.montana.edu/orc/radiation/training.html>

* Initial training for laboratory workers and PI’s supervising radiation work is covered in the Radiation Generating Equipment Safety, which is offered quarterly. This training course includes an assessment exam upon completion and is presented by the RSO.
* If you must use radiation generating equipment before attending a quarterly laboratory safety course, you may request a personal training session from the RSO.
* If you require additional security training, *per NRC regulations under 10 CFR Part 37*, contact the RSO for scheduling an additional course in Radiation Safety and Security.
* For use of nuclear gauges in laboratory or field environments, an online course on nuclear gauge safety is required and can be completed at: <https://www.apnga.com/courses/nuclear-gauge-safety-certification-course-sign-up/>.

Submission of completion certificate to the RSO is required prior to usage.

***Retraining Frequency***

Full training for Users of Equipment Containing Sealed Sources is required every three years. Two refresher trainings are required between full trainings (approximately annually), with the exception of users of 63Ni electron capture devices. In order to satisfy this requirement, you can:

* Take a User of Equipment Containing Sealed Sources refresher training course online through the *Radiation Safety Program* course housed on D2L, or
* You can request an in-service presentation for a laboratory: The same general material will be presented as in the refresher course but can be streamlined to fit the needs of the group.
* Full training can be requested by contacting the RSO at any time.

**INSTRUCTIONS TO ANCILLARY RAM LABORATORY WORKERS**

***Instructions Content***

Ancillary laboratory workers are defined as personnel who work in radiation areas to perform their duties but have no direct use of radioactive material or radiation generating equipment. This includes personnel working in laboratories with sealed and unsealed sources, which are not exempt from regulatory control. The ancillary instruction program, for those working around but have no direct contact with radioactive material or radiation producing machines, includes the following components:

* Indication of the presence of RAM through signage at the entrance to locations in which RAM is located.
* Posting of NRC Form 3 – Notice to employees so that it is observed on the way to and from locations where RAM is housed.
* Proper labeling of RAM use, storage and waste areas
* A general laboratory safety course is recommended for all ancillary RAM laboratory workers and can be requested at any time through SRM.

**Open Source Radioactive Material Users**

**Open Source RAM**

Open source radioactive materials encompass all radioactive materials that are not encased in a capsule designed to prevent leakage or escape of radioactive material.

**Laboratory Radiation Safety Practices**

**General Guidelines**

* Radioactive material users will familiarize themselves with the experimental protocols, special precautions, and any required equipment prior to performing the procedure.
* Before attempting an experiment for the first time, Authorized Users (AUs) should perform a 'dry run', using water or saline instead of the radioisotope solution.
* Work only in designated areas.
* Immediately report any unsafe situation to the Principal Investigator, and to the Radiation Safety Officer.

**Personal Protective Equipment (PPE)**

* Wear a laboratory coat or other protective clothing, disposable gloves, close-toed shoes and eye protection at all times when using radioactive materials.
* PPE such as lab coats and gloves should not be worn outside the laboratory.

**Contamination Control**

* All work bench areas must be covered with absorbent paper. Absorbent paper must be checked for contamination after each use.
* Whenever possible, work with radioactive solutions or storage of liquid radioactive solutions should be confined to a tray or vessel capable of containing the entire volume of the radioactive material being used.
* Before beginning an experiment, assemble all materials, reagents and equipment necessary to perform the experiment.
* Monitor hands, shoes, and clothing for contamination after each procedure or before leaving the area.
* Perform contamination and radiation surveys as directed. Record the results on the *Inventory and Tracking Sheet*.
* Do not eat, drink, smoke, apply cosmetics or change contact lenses in any area where radioactive material is stored or used.
* Do not store food, drink, or personal effects in areas where radioactive material is stored or used.
* Never pipette by mouth.
* Dispose of radioactive waste only in designated, approved, labeled and properly shielded receptacles.

**Exposure Control**

* Shielding materials must be available for specific isotopes used in the lab. Use lead shielding for gamma emitters; Plexiglas for high energy beta emitters.
* Radioactive materials must be adequately shielded on all sides to maintain exposures at less than 2 mR/hr at 30 cm from the source.
* If applicable, wear film badges at all times while in areas where radioactive materials are used or stored. Badges should be worn at chest or waist level. When film badges are not being worn to monitor occupational exposure, they should be stored in a designated low background area.
* All unstable and/or volatile radioactive materials must be used in chemical fume hoods.
* Follow any additional safety precautions provided by the radioisotope manufacturer or vendor. Maintain a copy of any package inserts.

**Labeling**

* All countertops where radioactive materials are used must be clearly defined and labeled with the radiation symbol.
* All hoods in which radioactive materials are used must be clearly labeled with the radiation symbol.
* All sinks in which radioactive material is introduced by cleaning of contaminated lab ware must be clearly labeled with the radiation symbol.
* Any equipment in which radioactive material is used must be clearly labeled with the radiation symbol (*Centrifuges, incubators, etc.).*

**Wipe Tests and Geiger Surveys**

**Geiger Survey**

Geiger counters (GM) are portable instruments used to detect ionizing radiation and can also be used to survey areas for ambient radiation dose rates (“area surveys”), providing the correct detector is used.

The Geiger counter is the least expensive, fastest and generally the most reliable means of detecting and measuring radioactive contamination. The beta pancake detector is used with the Geiger counter for finding and measuring beta radiation, and will detect all beta radioisotopes used at MSU except H-3 and Ni-63. It does not detect those nuclides because their betas are too low in energy to penetrate the window of the detector. Radioisotopes which may be detected with the beta pancake are C-14, S-35, P-33, P-32 and most other beta emitting nuclides.

The low energy gamma probe is used with the Geiger counter to detect and measure gamma radioisotopes of various energies. It is most efficient for I-125, but will perform adequately for Cr-51, Co-57 and other gamma emitting nuclides. These detectors will also detect low energy x-rays, such as those emitted by beta emitters producing Bremsstrahlung radiation.

**Wipe Tests**

Wipe tests are performed to detect and quantify radioactive contamination on surfaces of work areas and/or 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 germanium gamma counter. For low energy beta emitters such as H-3 and Ni-63, this is the appropriate method for contamination surveys.

**When to Perform**

Dose-rate surveys, at a minimum, must be performed in locations where workers are exposed to radiation levels that might result in radiation doses in excess of 2 mrem/hr. Contamination surveys must be performed:

* To evaluate radioactive contamination that could be present on surfaces of floors, walls, laboratory furniture, and equipment.
* After any spill or contamination event.
* To evaluate contamination of users and the immediate work area at the end of the day in which radioactive material was used.

**How to Perform**

An approved and calibrated survey meter must be used when conducting an area or contamination survey. Calibration of survey equipment must be performed annually.

* **GM Surveys**
	+ Check that the meter has been calibrated within the last year
	+ Check that the battery is within range
	+ Turn the probe to the lowest setting available
	+ Dose-rate surveys are performed at a distance of 30 cm from any source or surface
	+ Contamination surveys are performed at a distance of 1 cm from a surface and moving with a speed of 4-5 cm/s.
* **Wipe Tests**
	+ With an absorbent material, such as a piece of clean filter paper, wipe an area to be tested.
	+ Analyze the wipe in an appropriate counting instrument
	+ Convert results to dpm above background using the appropriate efficiency for the counter

**Action Levels**

* **GM Surveys**
	+ Dose Rate Survey – Any measurements above 2mR/hr at 30 cm from a source/surface or at 1 cm from skin/clothing.
	+ Contamination Survey - Any measurements above twice background should be cleaned and re-evaluated. If measurements are not reduced to background after cleaning, then a wipe test of the area should be performed to quantify the removable contamination present. At this time also notify the RSO.
* **Wipe Tests**
	+ Any contamination found shall be cleaned to background levels when possible
	+ If it is not possible to get to background levels, notify the RSO
	+ The RSO will work with AUs to ensure that contamination levels are below the following values:
		- I-125 – 20 dpm/100cm2 of removable contamination
		- All other isotopes – 1000 dpm/100cm2 of removable contamination

**Security of Radioactive Materials**

MSU is responsible for developing and implementing procedures to ensure the security and safe use of all licensed material from the time it arrives at their facility until it is used, transferred. and/or disposed of.

All licensed materials that are stored in controlled or unrestricted areas must be secured from unauthorized access or removal, so that individuals who may not be knowledgeable about radioactive materials cannot be exposed to or contaminated by the material, and individuals cannot take the material. When any licensed materials are in use they must be under constant surveillance so that the radiation worker can prevent others from becoming contaminated by or exposed to the material, or prevent persons from removing the material from the area.

Examples of acceptable methods for securing material are:

* Constant surveillance of radioactive materials by an AU
* Restricting laboratory access to only AUs
* Using locked containers in which only AUs have access to

**Inventory**

The inventory of radioactive materials from receipt to disposal is required. Users of open source radioactive materials are required to document receipt, use, and waste generation on each day these events occurs. The documentation is done through an *Inventory and Waste Tracking* spreadsheet located within the Brightspace Learning Environment by D2L located at:

<https://ecat1.montana.edu/?target=%2Fd2l%2Fhome>

Once a protocol for use has been approved by the RSC, authorized users are enrolled in an ongoing course titled *Radiation Safety Program.* The *Inventory and Waste Tracking* spreadsheet is located under a group folder with access restricted to AUs under the protocol. Group lockers are located under course resources:



Once in the group locker the excel spreadsheet can be opened. After changes are made, the file needs to be saved to a known location (such as your desktop) and then uploaded back into the group folder. **It is important to replace the original sheet with your updated one.** Only one file, the most recent one, should ever exist in the folder.

 When an order is received the sheet must be updated with:

* An identifying label from the storage container
* The chemical form of the material
* Solid or liquid form
* AU that received the package
* Delivery date
* Original order activity

On each day usage occurs the sheet must be updated with:

* Usage date
* Authorized user
* Lot/Order number
* Original order activity
* Waste stream distribution
* Activity left in storage after usage
* Contamination Survey Results

**Waste**

All waste streams must be approved prior to generation by the RSO and RSC. Any generation of a mixed chemical and radioactive waste will be avoided if at all possible due to the large cost of disposal. Radioactive waste is required to be placed in waste containers that are approved by the RSO. Separation of waste is done first by half-life (>120 days, <120 days), forms (solid, liquid, LSV) and in some cases by isotope (H-3/C-14, other isotopes).

**Waste from isotopes with a half-life of less than 120 days**

Waste from isotopes with half-lives of less than 120 days is placed in a decay in storage program. Waste falling into this category is held for a minimum of 10 half-lives and then disposed of as non-radioactive waste saving thousands of dollars annually in disposal costs. This waste is segregated into three streams – Solid, Liquid and Liquid Scintillation Fluid/Containers. LSC waste can be kept in flats when placed in secondary containment.

**Waste from isotopes with a half-life of greater than 120 days**

Waste from isotopes with half-lives of greater than 120 days will require disposal via a radioactive waste broker. This is a very costly expense therefore the weight and volume of waste should be kept at a minimum. This waste stream is segregated into three streams – Solid, Liquid and Liquid Scintillation Fluid/Containers. LSC waste can be kept in flats when placed in secondary containment.

**H-3 and C-14 LSC waste**

H-3 and C-14 LSC waste is separated from other waste in order to take advantage of a reduced cost of disposal of this particular type of waste stream

**Sharps**

Sharps with radioactive materials and contamination must be place in biohazard sharps containers and separated by the above guidelines

**Animals**

Contact the RSO for guidance

**Drain Disposal**

Drain disposal of radioactive materials is not allowed. Only simple instrument washes are allowed in a sink.

**Pick-Up requests**

When a waste container is approximately ¾ full a waste pick-up request is made. The request is made online through the following link:

<http://www.montana.edu/srm/forms/waste/>

**Shipping and Receiving**

Radiation Safety will receive all packages containing radioactive materials. Each package will be checked for contamination and contents prior to delivery. The RSO must be contacted prior to placing an order and be provided with a tracking number once an order has been placed. If a new account is required to be setup, contact the RSO for assistance with setting it up with the provider.

All packages should be shipped to:

**Attn: Nick Childs, RSO**

**1160 Research Drive**

**Bozeman, MT**

**59718**

**Transportation and Transfers**

Any transportation or transfer of radioactive materials must be approved by the RSC prior to being conducted. Transportation by vehicle will require additional HAZMAT training outside of the Open Source RAM training course. Contact the RSO for guidance on approval and additional training requirements.

**Inspections**

Laboratory inspections are conducted periodically. The inspection cycle may consist of a self-inspections, announced inspections and/or unannounced inspections. Inspection criteria is available upon request.

**Accidents, Incidents and Emergencies**

**PERSONAL CONTAMINATION**

Any personal contamination must be reported to the Radiation Safety Office immediately. Contaminated skin should be washed with mild soap and water. Contaminated clothing must be removed promptly and folded inward to prevent the spread of contamination. The clothing should then be placed in a plastic bag and labeled for decay or disposal as radioactive waste by radiation safety. The Radiation Safety Office will record contamination levels observed and procedures followed for incidents involving contamination of individuals. An incident record will be documented that includes names of individuals involved, description of work activities, calculated dose, probable causes (including root causes), steps taken to reduce future incidents of contamination, times and dates, and the surveyor's signature.

**Injury**

IN THE EVENT PERSONNEL ARE INJURED, SEEK MEDICAL ATTENTION IMMEDIATELY! Employee incidents are reported to Safety and Risk Management. Inform your supervisor, staff leadership, or safety representative.

**Spills**

The decision to implement a major spill procedure instead of a minor spill procedure depends on many incident specific variables, such as the number of individuals affected; other hazards present; the likelihood of spread of contamination; and types of surfaces contaminated as well as the radiotoxicity of the spilled material.

As a general guideline, a spill involving more than 100 µCi of radioactive material or more than one liter of radioactive liquid is a major spill which must be reported immediately to the Radiation Safety Office. The initial responder can determine if the clean-up will require additional radiation safety assistance.

**Minor Spills of Liquids and Solids (<100 µCi and non-volatile)**

* Notify persons in the area that a spill has occurred.
* Prevent the spread of contamination by covering the spill with absorbent paper. (Paper should be dampened if solids are spilled.)
* Clean up the spill, wearing disposable gloves and using 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. Put contaminated gloves and any other contaminated disposable material in the bag.
* Survey the area with an appropriate radiation survey meter set on lower scale. Check the area around the spill for contamination. Also check hands, clothing, and shoes for contamination.
* Report the incident to the Radiation Safety Office promptly.
* Cooperate with radiation safety personnel in discovering the root cause of the spill and in providing requested bioassay samples if indicated.

**Major Spills of Liquids and Solids (>100 µCi or volatile)**

* Notify all persons not involved in the spill to clear the room, but to remain in the area to await survey.
* Prevent the spread of contamination by covering the spill with absorbent paper (paper should be dampened if solids are spilled), but do not attempt to clean it up. To prevent the spread of contamination, limit the movement of all personnel who may be contaminated.
* Shield the source only if it can be done without further contamination or significant increase in radiation exposure.
* Close the room and lock or otherwise secure the area to prevent entry. Post the room with a sign to warn anyone trying to enter that a spill of radioactive material has occurred.
* Notify the Radiation Safety Office immediately.
* Survey all personnel who could possibly have been contaminated. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and then washing with a mild soap.
* Allow no one to return to work in the area unless approved by radiation safety personnel.
* Cooperate with radiation safety personnel in discovering the root cause of the spill and in providing requested bioassay samples if indicated.
* Follow the instructions of the Radiation Safety Office staff concerning decontamination techniques, surveys, provision of bioassay samples and requested documentation.

**Incidents Involving Dust, Mist, Fumes, Organic Vapors or Gases**

* Notify all personnel to vacate the room immediately.
* 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.
* Vacate the room. Seal the area, if possible.
* Notify the Radiation Safety Office immediately.
* 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.
* Survey all persons who could have possibly been contaminated. Decontaminate as directed by Radiation Safety Office personnel.
* Promptly report suspected inhalation and ingestions of radioactive material to the Radiation Safety Office.
* Decontaminate the area only when advised and/or supervised by the Radiation Safety Office.
* Allow no one to return to work in the area unless approved by the Radiation Safety Office.
* Cooperate with radiation safety personnel in discovering the root cause of the incident and in providing requested bioassay samples if indicated.
* Follow the instructions of the Radiation Safety Office staff concerning decontamination techniques, provision and collection of bioassay samples, and providing requested documentation.

**Minor Fires**

* Immediately attempt to put out the fire by approved methods (e.g., fire extinguisher) if other fire hazards or radiation hazards are not present.
* Notify all persons present to vacate the area and have one individual immediately call the fire department and Radiation Safety Office.
* Once the fire is out, isolate the area to prevent the spread of possible 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.
* In consultation with Radiation Safety Office, determine a plan of decontamination and the types of protective devices and survey equipment that will be necessary to decontaminate the area.
* Allow no one to return to work in the area unless approved by the Radiation Safety Office.
* Cooperate with radiation safety personnel in discovering the root cause of the incident and in providing requested bioassay samples if indicated
* Follow the instructions of the Radiation Safety Office staff concerning decontamination techniques, provision and collection of bioassay samples, and providing requested documentation.

**Major Fire, Explosion or Major Emergencies**

* Notify all persons to vacate the area immediately.
* Notify the fire department.
* Notify the Radiation Safety Office and other facility safety personnel.
* Upon arrival of firefighters, inform them where radioactive materials are stored or where radioisotopes were being used; inform them of the present location of the radioactive material and the best possible entrance route to the radiation area, as well as any precautions to avoid exposure or risk of creating radioactive contamination by use of high pressure water, etc.
* Cooperate with radiation safety personnel in discovering the root cause of the incident and in providing requested bioassay samples if indicted.
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* Follow the instructions of the Radiation Safety Office staff concerning decontamination techniques, provision and collection of bioassay samples, and providing requested documentation.

**Release into Environment**

Immediately report to the Radiation Safety Office any unplanned release of radioactive material into the environment. The Radiation Safety Office will determine, based on the quantity released, if the event is required to be reported to the NRC.

**Missing Radioactive Material**

Once a loss of radioactive material has been discovered, it must be immediately reported to the Radiation Safety Office. The Radiation Safety Office will:

* Gather information regarding the disappearance of the radioactive material;
* Initiate steps to locate and recover the material;
* Determine if the loss is required to be reported to the NRC according to regulations, and
* If required, report the loss in the required time frame.

**Sealed Source Radioactive Material Users**

**Sealed Source RAM**

Sealed source means any byproduct material that is encased in a capsule designed to prevent leakage or escape of the byproduct material.

**Exposure Control**

* Shielding materials must be available for specific isotopes used in the lab. Use lead shielding for gamma emitters; Plexiglas for high energy beta emitters.
* Radioactive materials must be adequately shielded on all sides to maintain exposures at less than 2 mR/hr at 30 cm from the source.
* If applicable, wear film badges at all times while in areas where radioactive materials are used or stored. Badges should be worn at chest or waist level. When film badges are not being worn to monitor occupational exposure, they should be stored in a designated low background area.

**Labeling**

* Any equipment in which radioactive material is used/housed must be clearly labeled with the radiation symbol*.*

**Leak Tests and Geiger Surveys**

**Geiger Survey**

For some gamma emitters (Co-57, Cs-137) a Geiger survey is required upon entry into the laboratory. This to ensure that the sealed source is properly shielded and has not been altered from the normal operating state. Consult the associated approved RAM protocol for the procedural steps.

**Leak Tests**

For sealed sources with activities of 100 µCi or greater a leak test is required at an interval not to exceed six months. Leak tests are performed and documented by radiation safety

**How to Perform**

An approved and calibrated survey meter must be used when conducting an area or contamination survey. Calibration of survey equipment must be performed annually.

* **GM Surveys**
	+ Check that the meter has been calibrated within the last year
	+ Check that the battery is within range
	+ Turn the probe to the lowest setting available
	+ Dose-rate surveys are performed at a distance of 30 cm from any source or surface
	+ Contamination surveys are performed at a distance of 1 cm from a surface and moving with a speed of 4-5 cm/s.
* **Leak Tests**
	+ With an absorbent material, such as a piece of clean filter paper, wipe an area to be tested.
	+ Analyze the wipe in an appropriate counting instrument
	+ Convert results to DPM above background using the appropriate efficiency for the counter

**Action Levels**

* **GM Surveys**
	+ Dose Rate Survey – Any measurements above 2mR/hr at 30 cm from a source.
* **Leak Tests**
	+ Any contamination found shall be investigated by radiation safety and cleaned to background levels when possible
	+ If it is not possible to get to background levels the RSO will work with AUs to ensure that contamination levels are below the following values:
		- I-125 – 20 DPM/100cm2 of removable contamination
		- All other isotopes – 1000 DPM/100cm2 of removable contamination
	+ If the amount of removable contamination during a leak test exceeds 0.005 µCi, the source is considered to be leaking and requires reporting to the NRC in a timely manner. Reporting of leaking sealed sources is a responsibility of the RSO.

**Security of Radioactive Materials**

MSU is responsible for developing and implementing procedures to ensure the security and safe use of all licensed material from the time it arrives at their facility until it is used, transferred. and/or disposed of.

All licensed materials that are stored in controlled or unrestricted areas must be secured from unauthorized access or removal, so that individuals who may not be knowledgeable about radioactive materials cannot be exposed to or contaminated by the material, and individuals cannot take the material. When any licensed materials are in use they must be under constant surveillance so that the radiation worker can prevent others from becoming contaminated by or exposed to the material, or prevent persons from removing the material from the area.

Examples of acceptable methods for securing material are:

* Constant surveillance of radioactive materials by an AU
* Locking a laboratory whenever no AUs are present
* Using locked containers in which only AUs have access to

**Inventory**

Physical verification of all sealed sources in possession under MSU’s license is conducted every six months by radiation safety.

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**Waste**

The disposal costs of sealed sources must be budgeted prior to approval for use and before being purchased. Depending on the isotope and activity these costs can range from $100 to $250,000 and should be considered when writing proposals for funding and usage.

**Shipping and Receiving**

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