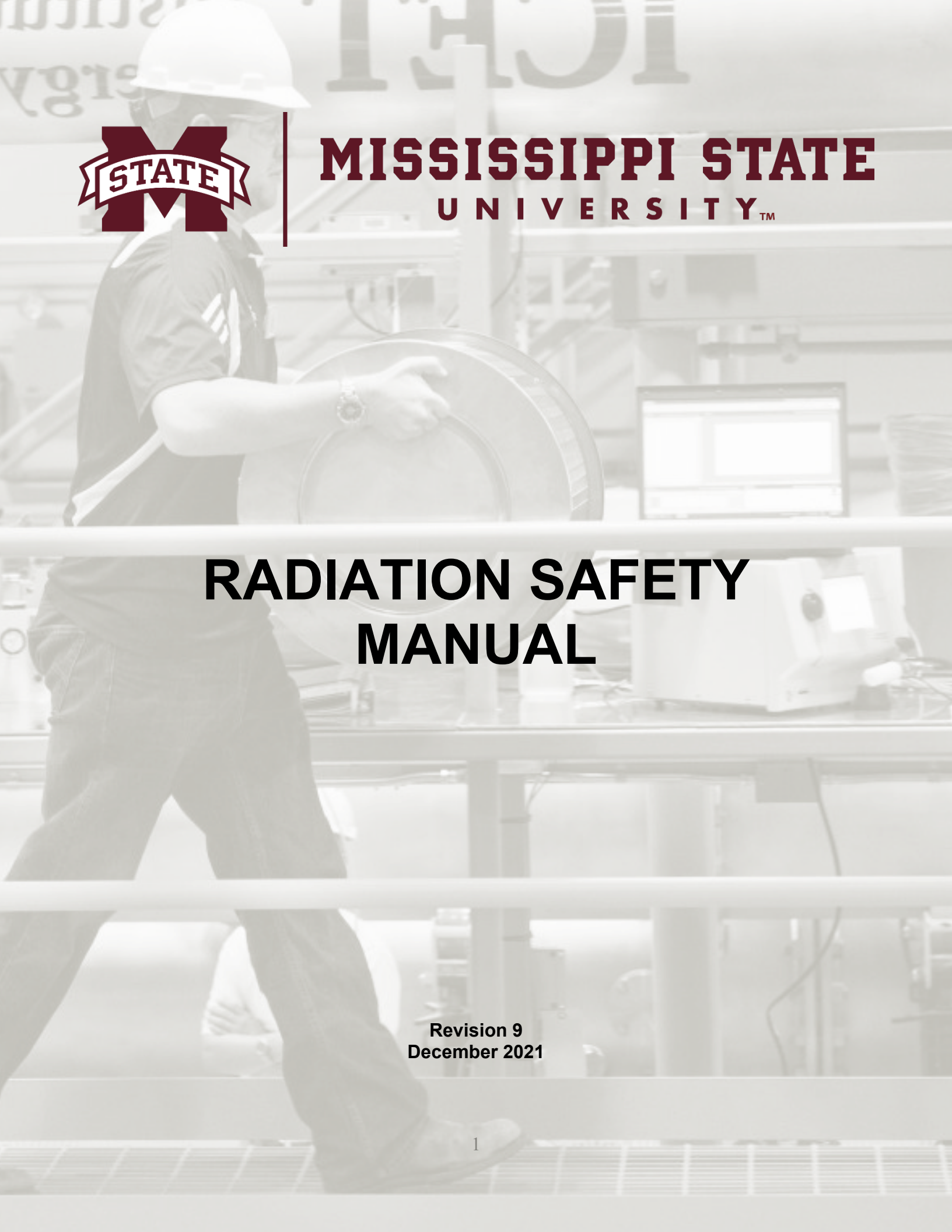

MISSISSIPPI STATE UNIVERSITY™

RADIATION SAFETY MANUAL

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SECTION 0.1 INTRODUCTION

Radioactive materials and machines emitting ionizing radiation are used in teaching and research activities at Mississippi State University (MSU). The Environmental Health and Safety Office (EHS), Radiation Safety Officer, and the Radiological, Chemical, and Laboratory Safety Committee are responsible for promoting the safe use of ionizing radiation at MSU.

All activities involving radioactive materials and devices emitting ionizing radiation must be conducted in a safe fashion consistent with all applicable state and federal regulations. MSU is committed to compliance with all such regulations.

SECTION 0.2 DEFINITIONS

Throughout this manual, the following terms are used. These terms are explained below.

“ARSO” – Acting or Assistant Radiation Safety Officer
"ALARA" – As Low As Reasonably Achievable
“ALI” – Allowable Limit on Intake
"Authorized user" – A faculty or staff member of Mississippi State University authorized by the Radiological, Chemical, and Laboratory Safety Committee to obtain and use radioactive materials
"Campus" – The Starkville, MS campus of Mississippi State University
“CFR” – US Code of Federal Regulations
"Chairman" – Chairman of the Radiological, Chemical, and Laboratory Safety Committee
"Committee" – MSU Radiological, Chemical, and Laboratory Safety Committee
“CPM” – Counts per minute
“DPM” – Disintegrations per minute
"DRSR” – Departmental Radiation Safety Representative
“GM counter” – A detector employing a Geiger-Muller gas filled tube
"EHS" – Mississippi State University Environmental Health and Safety Office
“EPA” – US Environmental Protection Agency
"Head" – A Department Head or Director
“IATA” – International Air Transporters Association
"ICRP" – International Commission of Radiological Protection
"MIRD" – Medical Internal Radiation Dose Committee
“MSDEQ” – Mississippi Department of Environmental Quality
“MSDH” – Mississippi State Department of Health
“MS-EBL-02" – Broad scope radioactive materials license issued to Mississippi State University by the MS State Department of Health
“NRC” – US Nuclear Regulatory Commission
“NIST” – National Institute of Standards and Technology
"NVLAP" – National Voluntary Laboratory Accreditation Program
"RCRA" – Resource Conservation and Recovery Act
"RSO" – MSU Radiation Safety Officer
"University" – Mississippi State University
“DOT” – US Department of Transportation

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SECTION 1 GENERAL PROVISIONS

SECTION 1.1 RADIOLOGICAL, CHEMICAL, AND LABORATORY SAFETY COMMITTEE

SECTION 1.1.1 GENERAL RESPONSIBILITIES OF THE RADIOLOGICAL, CHEMICAL, AND LABORATORY SAFETY COMMITTEE

The Radiological, Chemical, and Laboratory Safety Committee is responsible for the oversight of all activities utilizing radioactive materials at MSU. The Committee is responsible for ensuring that the University complies with all applicable state and federal regulations regarding the use of radioactive materials established by the Mississippi State Department of Health (MSDH), US Nuclear Regulatory Commission (NRC), US Environmental Protection Agency (EPA), US Department of Transportation (DOT), the University's radioactive materials license MS-EBL-02, and the *Radiation Safety Manual*. When deemed necessary, the Committee has the authority to impose additional requirements or standards on activities involving ionizing radiation.

The Committee has the authority to require that any use of radioactive materials, equipment emitting ionizing radiation, or services regulated in this document submit to such examination as the Committee deems necessary to assure safe operation.

The Committee establishes procedures for monitoring the use of radioactive materials and other sources of ionizing radiation. These procedures are designed to minimize the radiological risks to radiation workers and the public in accordance with the ALARA (As Low As Reasonably Achievable) concept.

The Committee reports to the Vice President for Research and Economic Development. A written report will be provided annually to the Vice President for Research and Economic Development summarizing the activities of the Committee.

The Committee is authorized to collect any radioactive materials used on campus improperly or without the permission of the Committee until all corrective actions deemed necessary by the Committee are implemented.

The Committee is authorized to review and approve any radioactive materials obtained or managed under MS-EBL-02 before material is procured or work begins (except as provided in section 1.5).

The committee is authorized to review and approve all forms used by the radiation safety program. A current list of forms can be found in Appendix D.

The Committee will meet at least quarterly, or more frequently if required, to assure compliance with University procedures and the MSDH *Regulations for Control of Radiation in Mississippi*. Minutes of each meeting will be maintained by the EH&S Office.

SECTION 1.1.2 ORGANIZATION OF THE COMMITTEE

The University Radiological, Chemical, and Laboratory Safety Committee shall consist of a minimum of six (6) voting members appointed by the Vice President for Research and Economic Development for a three-year term. No more than two voting members may be Departmental Radiation Safety Representatives. The minimum qualifications for voting members of the committee are given in Appendix F. The Committee shall have the authority to appoint a designated alternate for each voting member of the committee. In the event a member can't attend a meeting, that member's alternate may function as a voting member of the committee. All designated alternates shall meet the minimum qualifications established in Appendix F.

In addition to the voting members, the Committee may appoint other individuals to serve on the Committee in a non-voting advisory capacity. These advisors shall include such individuals as the campus Radiation Safety Officer (RSO), a representative from the Student Health Center, the Director of EHS, and other subject matter experts as necessary.

The Chair of the Radiological, Chemical, and Laboratory Safety Committee shall be appointed by the Vice President for Research and Economic Development. The minimum qualifications for the chair are given in Appendix F. The Chair shall be a voting member of the Committee.

All matters coming before the Committee must be approved by a simple majority of the voting members (or their designated alternates) of the committee. A quorum shall consist of at least half the voting members (or designated alternates), the Director of EHS, the RSO, and the Chair (or designated alternate). Presence of a quorum shall make a meeting official. Email votes are considered in the quorum determination. The results of all actions taken by the Committee will be recorded in the minutes.

The Chair may decide to allow committee business to be conducted by email or letter rather than convene a meeting of the Committee. Any decision made in this manner will be recorded in the minutes of the next official committee meeting.

SECTION 1.1.3 SPECIFIC RESPONSIBILITIES OF THE COMMITTEE

The Committee must review all proposed uses of radioactive materials at MSU. Anyone wishing to use radioactive materials on campus must submit an application (see appendix D) to the Committee. Only those projects approved by the Committee may be conducted.

The Committee or its designated representative has the authority to conduct inspections of all laboratories or areas where ionizing radiation is used under MS-EBL-02. If the Committee deems any practice unsafe, it may demand cessation of the project until a thorough review of the project is conducted and satisfactory procedures are implemented by project personnel.

The Committee will review and approve any proposed changes to the *Radiation Safety Manual* and the radioactive materials license amendment changes before submission to MSDH, Division of Radiological Health, with two exceptions. The RSO is authorized to request that radioactive sources no longer on campus be removed from the license and is authorized to request an extension of the expiration date to the radioactive materials license (sign the annual license renewal form) without committee review.

SECTION 1.1.4 SPECIFIC RESPONSIBILITIES OF THE CHAIR

The Chair reports directly to the Vice President for Research and Economic Development. The Chair is responsible for taking minutes of all Committee business. The Chair, with the assistance of the RSO, shall prepare the annual report for the Vice President of Research and Economic Development. The Chair shall have the authority to request meetings outside of the regular quarterly schedule when necessary. In the event of a disagreement between the RSO and an Authorized User, a resolution should be recommended by the Chair. The Chair has discretion to resolve the issue directly or to present the issue to the Committee. Any issue resolved directly by the Chair shall still be included in the Committee minutes.

SECTION 1.1.5 SPECIFIC RESPONSIBILITIES OF A DEPARTMENTAL RADIATION SAFETY REPRESENTATIVE

A department may elect to appoint a Departmental Radiation Safety Representative to assist with compliance with MSU's Radiation Safety Manual. This is an optional position and will depend on the individual department's unique radiation safety needs. Routine safety and compliance duties that can be performed by a Departmental Radiation Safety Representative are package surveys for radioactive material arriving on campus, weekly lab surveys, record keeping/management and reporting, inventory management, and special surveys. A Departmental Radiation Safety Representative may also be appointed to serve as a voting member of the Radiological, Chemical, and Laboratory Safety Committee.

A prospective Departmental Radiation Safety Representative must complete an application found in Appendix D. The application must be approved by the unit department head and the Radiological, Chemical, and Laboratory Safety Committee. An approval is department specific; a Departmental Radiation Safety Representative must submit a new application to serve in a different department.

SECTION 1.2 RESPONSIBILITIES OF THE RADIATION SAFETY OFFICER

SECTION 1.2.1 DUTIES OF THE RADIATION SAFETY OFFICER

The Radiation Safety Officer (RSO) is responsible for the daily management of the broad scope license MS-EBL-02. The minimum qualifications of the RSO are given in appendix F.

The RSO is responsible for radiation safety worker training, evaluation of proposed uses of radioactive materials on campus, shielding calculations, serve as the campus liaison for radiation matters with emergency responders, management of the radiation counting laboratory, manage the internal and external personnel monitoring programs, serve as the campus liaison with regulatory agencies regarding radiation issues, serve as university shipper for radioactive materials, and conduct routine monitoring of areas on campus where radioactive materials are used.

The RSO reports activities that are relevant to work on campus conducted under license MS-EBL-02 to the Committee. He/she is responsible for monitoring adherence to the regulations regarding radiological safety and health on campus. The RSO is authorized to enter any area on campus where radioactive materials or radiation emitting devices are used to conduct compliance or safety inspections. If unsafe practices or practices out of compliance with state or federal regulations regarding the use of radioactive materials or radiation emitting devices are observed, the RSO must immediately inform the authorized user. If measures are not undertaken immediately by the authorized user to remedy the deficiencies and prevent future occurrences, the RSO is authorized to secure the area and the radioactive materials or radiation emitting devices. A report must be filed immediately with the Chair of the Committee, the Director of EHS, the Vice President for Research and Economic Development, and the immediate supervisor of the authorized user.

The RSO assists and advises campus personnel on matters of radiological safety in such a manner as to assure a minimum of delay and inconvenience in projects involving the use of radioactive materials while maintaining compliance with all applicable regulations and MS-EBL-02.

The EHS Office and the RSO are responsible for maintaining adequate records to demonstrate compliance with all applicable regulations and MSEBL-02. These records shall be made accessible to the Committee, University administration, and the MSDH, Division of Radiological Health upon request.

If radioactive materials are obtained by individuals not approved by the Committee, the RSO is authorized to collect such materials for storage until proper approval is obtained.

In the event the RSO is off-campus but in contact with campus via phone or email, he/she may authorize others to operate on his/her behalf to perform limited duties or emergency response activities. The RSO is responsible for ensuring that all actions performed under his/her authorization are done in accordance with license MS-EBL-02 and all applicable regulations. In the event the RSO cannot be reached by phone or email, is incapacitated, and/or otherwise unable or unavailable to address the radiological safety needs of the university, the ARSO, or other qualified and Committee-approved individual, shall function as interim RSO and shall have the responsibility for ensuring all actions taken are consistent with license MS-EBL-02 and all applicable regulations.

SECTION 1.2.2 DUTIES OF ASSOCIATE RADIATION SAFETY OFFICERS

One or more Associate Radiation Safety Officers (ARSO) may be appointed to assist the RSO with daily management of the radiation safety program. Minimum qualifications for an ARSO are given in Appendix F. Specific duties and responsibilities of an ARSO will be given in writing at the time of appointment. ARSO's will train to function as an interim-RSO in the event that the RSO is temporarily unavailable.

SECTION 1.3 RESPONSIBILITIES OF AUTHORIZED USERS OF RADIOACTIVE MATERIALS

The authorized user is required to provide the Committee with information deemed necessary by the Committee or the RSO for compliance or safety. The authorized user must maintain records of all radioactive materials received so that an accurate campus inventory can be maintained. A quarterly RAM inventory report, including usage and disposal of such materials, must be made by each authorized user to the RSO.

The authorized user must report any lost, stolen, or missing radioactive material upon discovery to the MSU Police and the RSO. Suspicious actions of students, employees, or visitors to campus in or around radioactive materials labs or storage areas must be reported immediately to the MSU Police.

The authorized user must be familiar with the *Radiation Safety Manual*. These regulations and specific conditions required by the Committee must be followed at all times by personnel, students, and visitors working in areas approved for radioactive materials use.

All personnel, students, or visitors utilizing unsealed sources of radioactive materials must attend an MSU-sponsored safety seminar regarding the safe use of radioactive materials. The authorized user must verify that all individuals working under his/her supervision have completed this requirement.

Only permanent University employees can become authorized users. Students, temporary employees, and visitors must be supervised by an authorized user.

SECTION 1.4 RESPONSIBILITIES OF DEPARTMENT HEAD OR DIRECTOR

The Department Head or Director is responsible for the safety in all areas where radioactive materials are used within his/her department. The Head must verify the qualifications of all personnel and students receiving keys to radioactive materials laboratories within the department.

In the event an item of noncompliance or an unsafe practice is observed by EHS personnel, the Head will be informed immediately. The Head is responsible for assisting the RSO and the Committee in correcting the cited deficiencies.

When an authorized user terminates employment with the University, the Head should inform the RSO a minimum of 30 days before termination. The Head is responsible for the costs associated with decommissioning the lab(s) and/or equipment in restricted areas used by the authorized user. The decommissioning process will include the following:

(1) proper disposal of all radioactive waste;
(2) decontamination of equipment and lab space; and
(3) transfer or disposal of all radioactive materials to approved areas on campus.

The Department Head or Director is responsible for the collection of keys and termination of electronic access to radioactive materials work or storage areas when a student or employee terminates service with MSU or no longer needs access to these areas.

SECTION 1.5 APPLICATION PROCESS FOR OBTAINING RADIOACTIVE MATERIALS

Requests to obtain and use radioactive materials will be made on the application provided by the Committee (see Appendix D). The applicant must provide a detailed summary of experiments to be performed and his/her work experience with radioactive materials.

The RSO will preview the application and any necessary modifications will be recommended to the applicant. The application will then be presented to the Committee for review. The Committee can approve the application unconditionally, require modifications for approval, or deny approval.

In the event approval is needed before the next Committee meeting, interim approval may be granted jointly by the Chairman of the Committee and the RSO for use of any sealed source or of any material with an atomic number less than or equal to 83. Final approval is reserved for the Committee.

All approved projects using unsealed radioactive sources or any material with an atomic number greater than 83 must be reviewed by the Committee biannually as long as the project is active.

SECTION 1.6 AMENDMENT OF AN EXISTING APPLICATION

An authorized user must request approval from the committee to amend an existing application. A request for modification of an existing application should be made in writing to the RSO. A brief explanation of the item(s) requiring modification and a justification must be included.

In the event approval is needed before the next Committee meeting, interim approval can be granted jointly by the Chair and the RSO. Final approval is reserved for the Committee.

SECTION 1.7 PROCUREMENT OF RADIOACTIVE MATERIALS

When purchasing radioactive materials in any form, all requisitions must be approved by the RSO prior to purchasing or obtaining the material. The RSO cannot approve any request for radioactive materials other than radionuclides the applicant is approved to use in the quantities authorized by the committee. Anyone placing a requisition for radioactive materials must add the following words to the requisition: "This is Radioactive Material". Authorized users may also purchase radioactive materials with the “procard*” provided he/she is authorized to receive the material in the quantity and physical/chemical form requested.

* University purchasing card that functions similar to a credit card.

Authorized users purchasing materials with a standing purchase order must verify that the above conditions are satisfied before ordering any radioactive materials. All shipments received on campus that do not meet the above approval criteria will be stored by the RSO until an application or amendment to an application is completed.

The authorized user is responsible for verifying he/she is approved for the radionuclides in the quantity ordered on a procard. If unauthorized shipments of radioactive materials arrive onto campus, these materials will be collected by the RSO and will be disposed of unless approval is obtained by the Committee. The department ordering the material will be responsible for the disposal costs.

Requisitions for devices containing radioactive materials must be approved by the RSO prior to the issuance of a purchase order. If the device requested is available as a generally licensed device, the requisition will be approved by the RSO. However, the application to possess and use the device must be made by the faculty or staff member procuring the device. If the device is not distributed under a general license, the requisition must be processed like any other requisition for radioactive materials.

With the exception of sealed sources contained in devices requiring factory installation, all radioactive materials must be delivered to the Receiving Station located at 405 Garrard Road East in Starkville. Special advance arrangements must be made with the RSO for delivery to other locations.

SECTION 1.8 LIMITATIONS ON THE USE OF UNSEALED RADIOACTIVE MATERIALS

Unsealed radioactive materials are radioactive liquids, solids, or gases that can be removed from the shipping container and dispensed for use in an experiment.

Radioactive materials in the form of unsealed sources cannot be obtained under MS-EBL-02 without prior permission of the Committee.

All personnel and students working in a restricted area where unsealed radioactive materials are used must complete basic radiation safety training. The content of the radiation safety training is discussed in appendix E.

Materials supplied by the manufacturer as an exempt quantity are excluded from MSU licensing requirements and may be used at locations off campus without committee or MSDH approval.

The authorized user must properly maintain all safety equipment deemed necessary by the Committee. This includes at least an annual calibration of all portable survey instruments.

Radioactive materials cannot be used in experiments involving human subjects.

Radioactive materials cannot be used in any study involving the off campus environmental release of such materials without prior approval of the Committee. Any study that is likely to produce an off-site dose in excess of 50 millirem to any member of the public requires prior approval of the MSDH, Division of Radiological Health.

SECTION 1.9 LIMITATIONS ON THE USE OF SEALED RADIOACTIVE MATERIALS

Sealed sources are radioactive materials that are encapsulated usually in a metal capsule and will remain in the capsule during use.

Sealed sources must be used and maintained in accordance with instructions specified by the manufacturer of the device. Periodic leak tests must be conducted on all sealed sources at intervals recommended by the manufacturer of the device. If not specified, a leak test interval of six months is required. All leak tests will be performed either in accordance with the procedures specified in appendix G of this document or by a consultant licensed by the MSDH, the NRC, or another agreement state. Leak tests will normally be conducted by the RSO.

All sealed sources must be inventoried semiannually. This inventory is maintained by the RSO.

Unless specifically approved by the manufacturer of the device, no sealed source may be removed from its protective housing. If conditions require such removal, prior permission must be obtained from the MSDH, Division of Radiological Health.

SECTION 1.10 REQUIREMENTS FOR OBTAINING SOURCES OF RADIATION PRODUCED BY A DIFFERENCE OF ELECTRICAL POTENTIAL

When purchasing or obtaining devices containing x-ray tubes or a particle beam accelerator, the RSO must be notified before the unit is purchased or brought onto campus. The RSO may approve the purchase of such devices. The RSO has the authority to require Committee review when deemed necessary.

Any x-ray tube that is not a part of a Food and Drug Administration (FDA) certified cabinet x-ray device or a particle beam accelerator must be evaluated to determine shielding and other safety related requirements before purchase or delivery to campus.

The authorized user(s) of any campus x-ray device or particle accelerator listed on the device registration shall ensure that the device is operated safely in accordance with the registration, this manual, and other applicable University policies. Any person operating the device must complete general radiation safety training provided by the RSO and must receive instruction on the operation of the unit provided either by the authorized user or device manufacturer.

Any repair or modification that can potentially impact safety features or FDA certification must be completed by the manufacturer or other person specifically authorized by MSDH, Division of Radiological Health.

The authorized user is responsible for updating the unit registration as needed.

Disposal of an x-ray device or particle accelerator must be coordinated with the campus RSO.

The Committee and the RSO are authorized to require the operator(s) of such devices to use appropriate personnel monitoring devices in a manner consistent with this manual.

SECTION 1.11 APPROVAL OF NUCLEAR MEDICINE PROCEDURES AT MSU

Procedures utilizing therapeutic and diagnostic quantities of pharmaceuticals containing ^{131}I, ^{117m}Sn, and ^{99m}Tc may be conducted on both research animals and on animals received from members of the public. Due to the diversity of the procedures that may be required, the Committee will review each procedure utilized by the authorized user. Approval from the Committee is required before the initial use of the procedure and before any changes in the procedure are implemented.

Only unit doses of radiopharmaceuticals will be obtained for use.

The application for approval of nuclear medicine procedures must include the following information.

(1) The radionuclide(s) to be used and their chemical form(s).
(2) The dosage or dosage per unit mass that will be used.
(3) The species of the animal that will be utilized in the procedure.
(4) The expected biokinetics model that the compound will follow. The excretion paths must be specified.
(5) The method of administration of the drug. The Committee will not approve procedures requiring administration of a radioactive compound unless adequate shielding is provided to the hand.
(6) Specific procedures for the disposal of radioactive excreta. Radioactive animal excreta containing ^{99m}Tc may be discharged into the sewer system without regard to the activity. When practical, excreta containing ^{131}I will be held to allow decay before discharge into the sewer system. There are no excreta concerns for ^{117m}Sn.
(7) In locations where the animals will be housed while radioactive, the ventilation arrangements must assure that excessive concentrations of radioactive gases, vapors, or particulate will not exceed the limits or some fraction thereof for an unrestricted area.
(8) The following criteria will be utilized when the animal is released to an unrestricted area. Direct measurements at a distance of 1 foot from the animal will be used to establish a satisfactory release date satisfying dose constraints. In the case of animals containing ^{99m}Tc a limit of 1 mR/hr at 1 foot from the animal is permissible for unrestricted release. In the case of animals treated with ^{117m}Sn a limit of 0.45 mR/hr at 1 meter from the treatment site is permissible for unrestricted release.
(9) Instructions for safe handling will be provided to the owner when the animal is discharged from the clinic.
(10) All personnel (including support personnel such as caretakers) and students entering a restricted area will receive instruction in the safe handling of animals that contain radioactive materials.

Procedures involving ^{131}I in cats will require that bioassays on personnel entering the restricted area(s) be performed regularly in accordance with NRC Regulatory Guide 8.20. Campus bioassay procedures can be found in section 2.7. Air monitoring may also be used to determine concentrations of iodine present in the animal rooms and in adjacent unrestricted areas.

The following constraints will be followed when performing iodine procedures in cats:

(1) The maximum reading using a GM equipped meter shall not exceed 0.5 mR/hr at a distance of 1 foot from the cat.
(2) The animal will be held in a posted isolation area for a minimum of 96 hours after the administration of the iodine.
(3) The owner must sign a release and agree to prescribed handling instructions before the administration of the iodine.
(4) The iodine will be obtained from the pharmacy in unit doses in liquid form in quantities not to exceed 5 millicuries. The iodine solution will be injected from the syringe supplied from the pharmacy using a catheter into the cat. The catheter will then

be flushed with a non- radioactive solution. A syringe shield will be employed by the person administering the iodine.
(5) The administration will take place in a designated isolation room. Other than providing feed and water, the animal will not be handled or removed from the cage for a minimum of 72 hours post administration.
(6) The cat may receive limited veterinary treatment and care after 72 hours post administration inside the isolation room by trained campus radiation workers.
(7) If an animal dies while in the custody of the MSU College of Veterinary Medicine (CVM), the animal will be sealed in a plastic bag and held in a posted freezer until the ^{131}I has decayed to background. The animal will then be returned to the owner or disposed of by the CVM.
(8) The isolation room will be ventilated directly to the outside and will be maintained at negative pressure with respect to the occupied areas of the building.
(9) Solid radioactive waste will be containerized and remain in the isolation room for decay.
(10) The person administering the iodine solution will undergo a bioassay within 36 hours after the administration. Persons entering the room only to monitor the animal (feeding, watering, etc.) will receive a bioassay biweekly.

SECTION 1.12 APPEAL OF COMMITTEE ACTION

When an application to use radioactive material is denied or restrictions are added to proposed procedures, the authorized user will be informed in writing. The authorized user may request to meet with the committee regarding the mandated project requirements. The authorized user must contact the Chair in writing and state his/her objections to the committee decision. The authorized user is encouraged to propose alternatives to the restrictions and to consult with the RSO when developing these alternative protective actions.

When a project or approved user is suspended for safety or compliance reasons, the authorized user will be afforded the opportunity to meet with the Committee and/or the RSO to discuss the action. The approved user is encouraged to respond in writing to the actions taken.

Appeals or applicant meetings will be conducted at the next regularly scheduled committee meeting. If undue hardship will be placed on the approved user, he/she can request the Chair convene a special committee meeting. The decision to convene a special meeting rests with the committee Chair.

SECTION 2 RADIOLOGICAL SAFETY PROCEDURES

SECTION 2.1 INTRODUCTION

The requirements of this section are based on regulatory guidance and industrial standards. Compliance with the guidelines is required of all persons using radioactive materials or entering areas where radioactive materials are used. In the absence of specific guidance established in the *Regulations for Control of Radiation in Mississippi*, NRC regulatory guides may be used.

SECTION 2.2 GENERAL REQUIREMENTS

Radioactive materials may be used only in areas on campus approved by the Committee and the RSO. All areas must be posted in accordance with the requirements of Subchapter 4, *Regulations for Control of Radiation in Mississippi*.

All laboratories or storage areas must be keyed to prevent unauthorized entry. This requirement can generally be implemented by removal of the laboratory or storage area from the building master key.

Custodial and maintenance personnel must be escorted when in a posted lab by either the RSO, the approved user (or designee), or the department Departmental Radiation Safety Representative. Custodial or maintenance personnel must not be allowed to enter a contaminated area or repair contaminated equipment.

Auxiliary equipment required for the safe use of radioactive materials must be operable when radioactive materials procedures are being performed. This includes monitoring equipment, a properly operating fume hood if required by radioactive material procedures, and fire safety equipment if flammable materials are used in the lab.

Radioactive material in storage must be secured to prevent its unauthorized use or removal.

Safe lab practices must be employed at all times in areas where radioactive materials are used or stored. Reference Appendix A.

SECTION 2.3 PROTECTIVE CLOTHING

Protective clothing such as a lab coat, closed-toe shoes, and gloves is required of all persons using radioactive materials. Personal protective equipment used while handling radioactive materials shall be appropriate for the radiological and chemical hazards present. Depending on the procedures being performed, either part or all of the following may be required:

1. **Protective gloves –** Required when handling unsealed radioactive sources.
2. **Laboratory coat –** Required when handling unsealed radioactive sources.

3. Shoes – Shoes, not sandals, are required of everyone entering an area approved for the use or storage of radioactive materials.
4. Safety Glasses or a face shield – Required when handling radioactive materials under pressure or when splash is possible.
5. Lead apron or gloves – Required when handling large gamma or x-ray emitting sources frequently.
6. Coveralls – Required in areas where a high level of contamination is expected.
7. Shoe covers – Required when floor contamination is present or is expected.
8. Respiratory protection – Required when airborne radioactivity is present in sufficient concentrations to exceed limits set forth in Subchapter 4, *Regulations for Control of Radiation in Mississippi.*

SECTION 2.4 CONTAMINATION CONTROL

Contamination control shall be practiced by all persons working with radioactive materials that are dispersible. The following guidelines shall be employed in all areas where unsealed sources are manipulated.

1. Bench tops in the lab where radioactive materials are routinely manipulated must be smooth and nonabsorbent or covered with absorbent paper. Floors near work areas must be smooth and nonabsorbent or be protected with a floor mat.
2. All equipment and containers used to manipulate unsealed sources must be labeled with radioactive materials tape. These items must be monitored for contamination prior to release to an unrestricted area.
3. The use of an appropriate survey meter is required when contamination in excess of the limits specified for unrestricted release in NRC Regulatory Guide 8.23 is likely.
4. The use of appropriate protective clothing is required at all times when handling unsealed radioactive materials.
5. Areas in the laboratory where unsealed radioactive materials are routinely manipulated must be marked with radioactive materials tape, signs, tags, or equivalent.
6. Any area in a lab where unsealed radioactive materials are used is considered a restricted area until properly monitored and cleaned. In accordance with the ALARA concept, the item or location will be cleaned until background levels are obtained for both fixed and removable contamination. Decay may be used for radionuclides with a short half-life. When decay is not practical and cleaning efforts are ineffective and both fixed and removable contamination levels do not exceed the limits established in NRC Regulatory Guide 8.23, the item may be released to an unrestricted area or disposed of without regard to the remaining radioactive contamination.
7. Safe lab practices as defined in Appendix A shall be employed.

SECTION 2.5 TRANSPORTATION OF RADIOACTIVE MATERIALS ON CAMPUS

Transfer of radioactive materials from one approved area to another on campus is permitted provided that the RSO is consulted prior to the transfer. The authorized user receiving the

materials must be authorized by the Committee to receive the radionuclide(s) in the quantities to be transferred without exceeding an established possession limit.

When radioactive materials are moved through an unrestricted area, the materials must be packaged in a strong, tight container. Absorbent material must be present in sufficient quantity to absorb any leakage that might occur. The outer container must be labeled with radioactive materials tape, tags or stickers indicating the radionuclide(s), quantity present, and date. When radioactive sources in liquid or easily dispersible solid forms are involved, a double containment system must be used.

SECTION 2.6 STORAGE OF RADIOACTIVE MATERIALS

Radioactive materials must be stored only in areas approved by the Committee, the RSO, and posted in accordance with Subchapter 4, *Regulations for Control of Radiation in Mississippi*. Any cabinet, fume hood, or refrigerator used for radioactive materials storage must be labeled with radioactive materials stickers, tags, or tape. All containers of radioactive materials must be labeled with radioactive materials tags or tape listing the radionuclide(s), activity, and date.

The storage containers used must be suited to the radionuclides and the chemical forms of the compounds. Containers constructed with materials of low atomic numbers should be used to store beta emitters. Lead containers should be used to store x-ray or gamma emitting radionuclides. Corrosive or flammable materials must be stored in proper containers and should not be stored in areas where radioactive materials are stored.

Radioactive gases must be stored in an operable chemical fume hood or in well ventilated areas. Appropriate measures must be taken to prevent a release of gaseous radionuclide that could result in concentration exceeding the limit established in Subchapter 4, *Regulations for Control of Radiation in Mississippi*.

Liquid sources must be stored in a manner to prevent spillage or breakage.

Radioactive sources must be stored so that no one in an unrestricted area will receive a dose in excess of the limits established in Subchapter 4, *Regulations for Control of Radiation in Mississippi*. Doses to persons from stored radioactive materials in restricted areas must be kept as low as reasonably achievable.

SECTION 2.7 INTERNAL DOSE ASSESSMENT

Internal dose assessments will be performed in the event of a significant uptake of radioactive materials by either a radiation worker or a member of the public.

In performing internal dose assessments the data and calculations will be consistent with International Commission of Radiological Protection (ICRP) 30 or later revision. An assessment

of the radioactive materials up taken by an individual will be performed by one or more of the following methods:

(1) An estimate of uptake based on the quantity of radioactive materials involved.
(2) Air sample data.
(3) Excreta data.
(4) Direct measurements in the case of radioiodines.

Specific guidance as provided in Subchapter 4, *Regulations for Control of Radiation in Mississippi*, Regulatory Guide 8.20, and Regulatory Guide 8.32 will be applied when performing bioassays. The regulatory guides can be obtained from the EHS Office or may be obtained from the NRC website http://www.nrc.gov.

When a bioassay is performed to assess thyroid uptake of radioiodines, a shielded/collimated NaI detector will be used. The instrument will be calibrated using a suitable radiological standard with National Institute for Standards and Technology (NIST) or equivalent national standard traceability. A dose report will be filed in the MSU occupational exposure record file.

The bioassay for ^{125}I uptake studies will be performed using a collimated NaI detector calibrated with a NIST traceable iodine-125 or iodine-129 source loaded in a neck phantom. A calibration check will be performed before a bioassay. In the case of ^{131}I, the instrument will be calibrated initially using an ^{131}I NIST traceable standard. Calibration checks after the initial calibration may be performed using check source with a longer half-life such as ^{133}Ba.

The bioassay will consist of a three minute or longer background check and a one minute or longer measurement of the thyroid. Upon determination of the thyroid radioactive iodine burden, the actual inhalation uptake will be calculated using retention curves published by the ICRP or calculate using the ICRP methodology. The actual uptake will then be compared to the Allowable Limit on Intake (ALI) and a dose calculation will be performed.

SECTION 2.8 EXPOSURE LIMITS TO AN EMBRYO/FETUS

In accordance with *Regulations for Control of Radiation in Mississippi,* Subchapter 4, any pregnant student or employee working in a restricted area is encouraged to notify her supervisor and the RSO in writing as early in the pregnancy as possible. Upon receiving this notification, measures must be taken to limit exposure to the fetus to not more than 0.5 rem during the entire pregnancy. The dose to the embryo/fetus shall be the sum of (1) the deep dose to the pregnant woman and (2) the dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the pregnant woman.

The dose limits established in this section apply only after the University has been notified in writing of the pregnancy and established date of conception. If the embryo/fetus dose exceeds 0.5 rem or is within 0.05 rem of the limit at the time notification is made, the University is in

compliance provided that the embryo/fetus dose does not exceed 0.05 rem during the remainder of the pregnancy.

SECTION 2.9 COMPLIANCE WITH US DOT SHIPPING STANDARDS

Any shipment of radioactive material from the MSU campus will comply with all applicable DOT (or other applicable transportation) regulations and MSU Policy 79.09. Packages of radioactive materials must be prepared for shipment under the supervision of the RSO or by someone with the appropriate DOT training. All packages containing radioactive materials must be inspected by the RSO before being submitted to the carrier/transporter.

SECTION 2.10 CALCULATION OF SKIN DOSE

In the event of a skin contamination event, the dose will be calculated using Varskin. Another method of calculation may be used if deemed acceptable by the MSDH, Division of Radiological Health.

SECTION 3 RADIOACTIVE WASTE DISPOSAL

SECTION 3.1 INTRODUCTION

With the exception of waste streams specifically exempted in Subchapter 4, *Regulations for Control of Radiation in Mississippi,* all waste materials generated under license MS-EBL-02 will be processed as radioactive waste. These materials will be stored and labeled in accordance with the requirements established for the storage of radioactive materials.

All persons utilizing radioactive materials must implement necessary controls over laboratory operations to ensure that all contaminated items are properly labeled and stored.

The cost of waste disposal is the responsibility of the department generating the waste. Personnel are encouraged to obtain cost information on waste disposal before beginning a project. Waste minimization should be taken into account when planning a project.

Records of disposals will be maintained by the RSO.

SECTION 3.2 DISPOSAL OF COMBUSTIBLE MATERIALS

Combustible, non-Resource Conservation and Recovery Act (RCRA) radioactive waste is a common waste stream on campus. This waste consists of contaminated paper, plastic, and animal tissue. Radionuclides such as ^{3}H, ^{14}C, ^{35}S, ^{125}I, ^{32}P, and ^{51}Cr are commonly found in this waste stream. Generally, this waste stream has a low specific activity.

The method of disposal depends on factors such as volume of waste, available storage space, and cost of disposal. The options available are summarized below.

Radioactive waste with a half-life less than 120 days will be disposed of by one of the methods below:

a. Decay in storage – The waste container will be placed in a closed container and held until no significant radioactivity can be detected with normal survey instruments. A survey meter equipped with a thin window GM probe will commonly be used for high energy beta emitters. A NaI detector may be used for monitoring gamma and x-ray emitting radionuclides. A release survey will be conducted by the RSO or under the supervision of the RSO. The waste will be released when the measured net count rate is found to be at background levels.

b. Off-site shipment – The waste will be packaged in accordance with DOT requirements and transported off campus for disposal. The materials will be shipped to a facility licensed to accept radioactive waste.

Radioactive waste with a half-life of 120 days or greater will be packaged in DOT approved packaging and shipped to a facility licensed to accept radioactive waste.

SECTION 3.3 DISPOSAL OF LIQUID, NON-RCRA RADIOACTIVE WASTE

Liquid radioactive waste will be collected in the laboratory where generated. The liquid will be monitored to determine the activity of the radionuclide(s) present. Provided the limits specified in Subchapter 4, *Regulations for Control of Radiation in Mississippi*, are not exceeded and the waste is not regulated under RCRA, the waste liquids may be discharged into the sanitary sewer system. Radioactive solutions with both an atomic number greater than 92 and a half-life greater than 5 years may not be disposed of in the sewer system.

SECTION 3.4 NON-COMBUSTIBLE RADIOACTIVE WASTE

Non-combustible radioactive waste such as glassware and needles will be collected for disposal. Items contaminated with radionuclides with a half-life less than 120 days will be held for decay. The waste container will be sealed and held until no significant radioactivity can be detected with normal survey instruments. A survey meter equipped with a thin window GM probe will commonly be used for beta emitting radionuclides. A meter equipped with a NaI detector may be used for monitoring gamma and x-ray emitting radionuclides. The material will be treated as ordinary trash when no reading above normal background is measured.

Radioactive waste containing radionuclides with a half-life in excess of 120 days will be packaged in DOT approved packaging and shipped off site for disposal.

SECTION 3.5 MIXED WASTE

Waste generated that is radioactive and regulated under RCRA will be managed at the MSU radioactive waste storage facility or at another designated waste storage facility if generated off the main campus. Storage precautions will be implemented based on chemical and radiological properties of the material.

Any campus personnel handling the waste will receive radiological and chemical training in the safe handling and processing of the waste and training in the response and post cleanup monitoring of spilled mixed waste. The RCRA/chemical training will generally be satisfied by a current 40 hour hazardous waste operations and emergency response (HAZWOPER) certification.

SECTION 3.6 SEALED SOURCES

A sealed source or special form radioactive material may be returned either to the manufacturer or the source manufacturer for disposal. The return of the sources will be arranged by the RSO and records of the transfer will be maintained by the EHS Office.

SECTION 3.7 DEREGULATED LIQUID SCINTILLATION MEDIA

Liquid scintillation media including the vial, cap, and fluid that has a specific activity of less than .05 microcuries per gram of ^{14}C and/or ^{3}H is a deregulated radioactive waste in accordance with the *Regulations for Control of Radiation in Mississippi*, Rule 1.4.39. The chemical composition of the fluid will determine the disposal method. If the fluid is regulated under the RCRA standards, the fluid and possibly the vial and cap will be shipped to an EPA permitted treatment storage and disposal facility for disposal without regard to the radioactivity. If the fluid is a not a RCRA waste, the fluid may be discharged into the sanitary sewer system. If the fluid is removed before disposal, the vials and caps will be disposed of as ordinary trash.

SECTION 3.8 DEREGULATED ANIMAL TISSUES

Animal tissues containing less than .05 microcuries per gram of ^{14}C and/or ^{3}H will be shipped off site for disposal as radioactive waste, be incinerated as ordinary trash, or disposed of in some other manner that will ensure that the tissues will not be used for human or animal feed.

SECTION 4 MONITORING AND SURVEILLANCE PROGRAM

SECTION 4.1 INTRODUCTION

Depending on the radionuclides in use and the quantity of radioactive material used per experiment, the laboratory will be monitored either on a weekly or semi-annual basis. Laboratories utilizing only materials with a half-life less than 48 hours are exempt from routine weekly and semiannual surveys.

All semiannual inspections will be conducted by the RSO. Weekly inspections can be conducted by either the RSO or the Departmental Radiation Safety Representative.

Laboratories utilizing unsealed sources that meet any of the following criteria will be surveyed weekly at designated locations in the lab while experiments utilizing radioactive materials are performed if any of the following criteria are met:

1. The activity used per experiment exceeds ten times the exempt quantity for the radionuclide. The sum of ratios method will be used when more than one radionuclide is used in an experiment.
2. The laboratory has a history of contamination control deficiencies.
3. Special monitoring for ALARA is imposed.

With the exception of ^{3}H, either smears or an appropriate survey meter will be used to conduct this survey. Smears will be used to monitor for ^{3}H.

Semi-annual laboratory inspections will be performed by the RSO in all posted laboratories except those where radionuclide(s) with a half-life less than 48 hours are used.

The semi-annual inspection will consist of the following:

1. A minimum of six smears or readings made with an appropriately-calibrated survey meter will be performed at the following locations in the lab:
    a. Entrances to unrestricted areas;
    b. Benches where radioactive materials are used;
    c. Floors near radioisotope work areas;
    d. Inside fume hoods used for radioactive materials work;
    e. In at least one area in the lab where radioactive materials are not used; and
    f. At least one smear inside each refrigerator used to store radioactive materials.
2. A spot survey of the lab using portable instrumentation, unless only 3H is used.
3. Verification that the lab is posted with all appropriate signs.
4. A visual check of the lab to verify food is not consumed or stored in the lab.
5. Verification that personnel dosimetry is used appropriately.

Laboratories utilizing only radionuclides with a half-life less than 48 hours will generally be monitored only when radioactive materials are in use. A combination of smears and monitoring with survey instruments will be performed by either EHS Office personnel or laboratory personnel to verify that contamination levels do not exceed established regulatory limits. Area surveys will be performed in both restricted and unrestricted areas to verify that exposure rates are within established regulatory limits. Records of surveys will be maintained by either laboratory personnel or by the RSO.

Special surveys will be performed as needed. A significant spill of radioactive materials is an example of a situation requiring a special survey. Smears and/or instrument readings will be performed by EHS Office personnel. The results will be recorded and maintained by the RSO.

SECTION 4.2 SURVEYS OF PACKAGES

The University routinely receives shipments of radioactive materials. These packages are generally delivered to the Receiving Station located at 405 Garrard Road East, Starkville. Upon arrival, the receiving clerk is instructed to contact the RSO as soon as possible. EHS Office personnel will pick up the package for processing.

All Radioactive White I, Radioactive Yellow II, or Radioactive Yellow III packages of radioactive material will be processed in accordance with Rule 1.4.34, *Regulations for Control of Radiation in Mississippi*. The following data will be collected for nonexempt packages:

1. Transportation Index;
2. Surface contamination present on outer container;
3. Exposure rate on contact with the container and at 1 meter from the container;
4. General condition of the package.

Appropriate notification of nonconformance will be made to MSDH as required.

In some cases, packages of radioactive materials are delivered directly to the department by either the carrier or by receiving station personnel. When this nonstandard delivery occurs, laboratory personnel are instructed to place the package in an approved radioactive materials laboratory for storage and contact the RSO or the Departmental Radiation Safety Representative immediately. The package should not be opened until EHS Office personnel or the Departmental Radiation Safety Representative inspects the package.

SECTION 4.3 PERSONNEL MONITORING PROGRAM

Persons handling or utilizing gamma, x-ray, or high energy beta emitters in quantities that are likely to produce exposures in excess of 10% of the limit specified in Subchapter 4, *Regulations for Control of Radiation in* Mississippi will be assigned appropriate monitoring devices (film badge, TLD badge, etc.). Either quarterly or monthly badges will be used. However, if

circumstances dictate, badges can be exchanged on a less frequent basis with approval of the Radiological, Chemical, and Laboratory Safety Committee.

Persons likely to receive hand or finger doses in excess of 5 rem annually we will provided ring or other appropriate extremity dosimeter. Work conditions that will necessitate extremity monitoring are those situations in which persons are conducting studies on campus that use more than an average of 2 millicuries per week of gamma/high energy beta emitting radioactive material that is neither shielded or handled only with tongs (or equivalent). Extremity dosimeters may be required when persons are using x-ray devices or sealed sources and will be exposed to hand doses in excess of 5 rem annually.

The University will only use dosimeters supplied by a National Voluntary Laboratory Accreditation Program (NVLAP) vendor.

It is the responsibility of authorized users to verify that badges are exchanged within 5 working days of the designated exchange date. All badges must be returned with proper controls to the vendor. In the event the exchange date falls on a weekend or University holiday, the badges may be exchanged on the last working day before or the first working day after the weekend or holiday.

The EHS Office will maintain personnel exposure records. Annual exposure reports, termination reports, and occupational histories will be supplied in accordance with Subchapter 10, *Regulations for Control of Radiation in Mississippi*.

Any deviations from established policy in the monitoring program will be documented and presented to the Committee during regular meetings. Failure to use personnel monitoring devices properly is basis for the Committee to take disciplinary action. This action can include temporary or permanent revocation of permission to use radioactive materials and/or machines emitting ionizing radiation.

The intentional irradiation of radiation dosimeter to invalidate the reading is basis for permanent revocation of access to radioactive materials and/or machines emitting ionizing radiation.

Thyroid bioassay procedures will be conducted using a PGT multichannel analyzer and NaI detector or other suitable detector. The NaI with be placed in a collimated lead shield when the assay is performed. System calibration will be performed using a suitable NIST standard in a thyroid phantom.

SECTION 4.4 EMPLOYEE TRAINING PROGRAM

A basic radiation safety training program will be conducted by the Environmental Health and Safety Office for all faculty, staff, students, and visitors working routinely in laboratories

approved for radioactive materials use. This course will emphasize basic radiation safety. An outline of topics discussed in a typical training session is listed in Appendix E.

Any person working in a radioactive materials lab using unsealed radioactive material must complete an initial radiation safety class and complete a refresher class each year thereafter. Initial training consists of a review of basic radiation safety information before entering the lab and completion of the appropriate radiation safety class within 45 days of beginning work in the lab.

SECTION 4.5 EMERGENCY PROCEDURES

When a spill or uncontrolled release of radioactive materials occurs on campus, the RSO must be contacted immediately. The RSO will investigate and determine an appropriate response to the accident.

The following guidelines will be applied:

1. Lab personnel requiring medical attention will be assisted first.
2. Anyone contaminated in the accident will be monitored and decontaminated in accordance with procedures established in appendix C. When applicable, a dose assessment will be performed.
3. Any areas contaminated or suspected to be contaminated will be clearly posted "off limits" to unauthorized personnel. These areas will remain posted until decontaminated and monitored for residual contamination.
4. Contaminated areas or equipment will be monitored for residual radioactivity. In accordance with the ALARA principle, efforts will be made to clean radioactive contamination to background level. No item or area will be released until the level of residual contamination are below the limits established in US Nuclear Regulatory Commission Regulatory Guide 8.23.
5. If the total quantity of the radioactive material involved in the spill exceeds one exempt quantity of the radionuclide involved, a report of the incident will be made to the Committee at the next scheduled meeting. If required by Subchapter 4, *Regulations for Control of Radiation in Mississippi* a report will be filed by the RSO to the MSDH, Division of Radiological Health.

A detailed emergency response plan will be maintained by the RSO.

SECTION 4.6 ROUTINE MONITORING

Analysis of smears and samples are routinely conducted by the RSO to demonstrate compliance with the terms of the MSU radioactive materials license. The instruments used by MSU are:

1. Packard-Canberra liquid scintillation counter for analysis of smears and other samples of beta emitting materials.

2. ORTEC high purity germanium detector for analysis of x-ray and gamma emitters.
3. NaI detector and PGT multichannel analyzer for screening of gamma and x-ray emitters and thyroid bioassays.
4. Oxford Instruments proportional counter for smears and deposited samples of alpha (and some beta) emitters.
5. Other instruments are occasionally used when suitable analysis results can be obtained.

SECTION 4.7 AIR SAMPLING

When radioactive materials in large quantities are used in a chemical or physical form that is easily dispersible such as particulate matter, vapors, or gas, an air monitoring program may be required. Air samples will be collected and analyzed to determine airborne concentrations of radioactive materials. Stack sampling may be conducted to monitor effluents.

Reference NRC Regulatory Guides 8.25 and 8.37.

SECTION 4.8 URANIUM HANDLING

Projects using larger quantities of uranium and uranium compounds will be evaluated by the Committee to determine if air sampling is required. NRC Regulatory Guide 8.30 will be referenced when performing project evaluations.

Rooms or exterior locations where metallic unjacketed uranium metal is used must have either a Class D fire extinguisher or an equivalent quantity of class D extinguishing media for use.

SECTION 5 CALIBRATION PRACTICES AND PROCEDURES

SECTION 5.1 INTRODUCTION

All portable survey instruments used for monitoring radioactive materials on campus will be calibrated at least annually. The calibration will be performed as per instructions from the manufacturer or by accepted standard practices. Specifically, American National Standards Institute (ANSI) N-323-1978 was followed in preparing this document.

The procedures below may be used to calibrate all monitoring instruments at MSU.

SECTION 5.2 CALIBRATION EQUIPMENT

The following calibration equipment is available:

1. J. L. Shepherd model 28-6B single source calibrator equipped with a 3000 millicurie (original activity) ^{137}Cs source with attenuators. This unit was supplied with calibration curve traceable to the NIST. Survey meters equipped with standard wall GM probes will typically be calibrated with this unit.
2. J. L. Shepherd model 10-A portable beam calibrator equipped with a 10 millicurie (original activity) removable ^{137}Cs source with attenuator. This unit was supplied with calibration curve traceable to the NIST. Survey meters equipped with standard wall GM probes will typically be calibrated with this unit.
3. Isotope Products Laboratory gamma disk standards supplied with calibration data will be used to determine the efficiency of instruments to various gamma emitters.
4. Isotope Products Laboratory beta disk standards supplied with calibration certificates will be used to determine the efficiency of instruments to various beta emitters.
5. TMA Thermo Analytical, Inc. alpha disk standards supplied with calibration certificates will be used to determine the efficiency of instruments to various alpha emitters.
6. Other standards or sources produced locally or purchased. These standards might include solutions or sources in geometries required for special calibration needs. A calibration certificate will be kept on file as long as the standard is used.
7. Ludlum model 500 pulser.
8. Ludlum model 2200 scaler-ratemeter.
9. FEMA model 794 calibrator.

SECTION 5.3 CALIBRATION OF STANDARD SURVEY METERS EQUIPPED WITH GM TUBES

SECTION 5.3.1 INTRODUCTION

Survey meters equipped with standard GM tubes and/or thin window GM probes are commonly used on campus. The appropriate portions of the procedure listed in this section will be utilized during calibration.

SECTION 5.3.2 PRECALIBRATION EXAMINATION OF METER AND DETECTOR(S)

1. If the meter is equipped with batteries and a test circuit, a battery check will be made before calibration. The meter will not be calibrated unless the batteries are within the manufacturer's specifications.
2. If possible, the high voltage of the meter will be checked and set to the recommended value for the meter/probe combination.
3. Any visible damage will be noted. No calibration will be attempted if the meter or probe is damaged significantly.

SECTION 5.3.3.1 CALIBRATION OF A METER EQUIPPED WITH A STANDARD GM PROBE

If the meter is equipped with an exposure rate display, only that display will be calibrated. The count rate display may be checked if other secondary detectors will be used with the meter

SECTION 5.3.3.2 LINEAR READOUT INSTRUMENT

If adjustments can be made on each scale, the meter will be checked at approximately 20% and 80% full scale. If the "as-left" readings are within 20% of the known values, the instrument scale will be assumed functional.

If only one adjustment can be made, the midpoint of the middle scale or the calibration point suggested by the instrument manufacturer will be selected for calibration. The meter will be exposed to the selected radiation field and adjustment will be made. The meter will then be checked at the 20% point, midpoint, and 80% point of each scale. If the observed readings are within +/- 20% of the known values, the scale will be assumed calibrated.

Any scale not calibrated or found inoperable will be noted on the meter calibration label.

Any scale less than 1 mR/hr may require electronic calibration due to fluctuations generally observed with portable instrument readings in these low ranges. Electronic calibrations will generally be performed on instruments with only a count rate display.

SECTION 5.3.3.3 LOGARITHMIC READOUT INSTRUMENT

The point(s) of calibration will be selected per manufacturer's recommendations or at approximately the midpoint of the middle scale. The meter will be exposed to the radiation field and adjustments will be made. The meter will then be checked at the midpoint of each decade. The meter will be considered operable if the readings are within 20% of known values.

SECTION 5.3.4 CALIBRATION OF A SURVEY METER USED FOR DETECTION OF SURFACE CONTAMINATION

If the meter is equipped with a count rate display, this scale will be calibrated electronically. If the meter is equipped with only an exposure rate display, the procedure for calibration of a survey meter equipped with a standard GM tube will be followed.

The probe will be placed near (generally on contact with) calibrated beta, gamma, or alpha sources as appropriate and the observed count rate will be noted. A calibration factor between the observed count rate and exposure rate may also be prepared using the calibration units.

Calibration will include the calculation of observed net count rate to surface activity conversion factors. These factors will be applied to convert an observed count rate to a surface activity.

A conversion factor will be calculated for the detectors commonly employed on campus to perform contamination surveys.

The conversion factor will be calculated using calibrated "button" standards. The conversion factors will be performed using 4B emission data (with traditional efficiency calculation methods) and/or 2B emission data (with ISO calculation methods). Selection of the appropriate conversion factor to use with collected field data will be done in accordance with good health physics practices.

SECTION 5.4 CALIBRATION OF THE GAS FLOW PROPORTIONAL COUNTER

When counting smears, calibrated standards will be used to determine the counting efficiency as disintegrations per minute/counts per minute (DPM/CPM). When available, a standard containing the radionuclide of interest will be used. If specific standards are not available, the efficiency will be determined using a ^{36}Cl standard and the alpha detection efficiency will be determined using either a uranium standard or a ^{210}Po standard.

"In house" standards may be prepared for other assays performed on the instrument.

SECTION 5.5 CALIBRATION OF HIGH PURITY GERMANIUM DETECTOR

Calibration of the High Purity Germanium Detector (HPGe) will be performed using calibrated multiline gamma standards. Typically geometries will include a Marinelli beaker and a filter paper (disk standard).

Efficiency and MDA calculations will be performed using Ortec Gammavision software supplied with the detector. Calibration will be performed annually.

SECTION 5.6 CALIBRATION OF LIQUID SCINTILLATION DETECTOR

The liquid scintillation counter will be calibrated using the standards supplied with the unit. Analysis software supplied with the unit will be used to determine the activity in liquid.

To determine the counting efficiency for smears by liquid scintillation analysis, the following procedure will be used. A filter paper will be spiked with a known quantity of ^{3}H and another with ^{14}C. The filters will be counted and an efficiency will be calculated. The ^{14}C efficiency will be used for other nuclides (if nuclide specific data is not available).

SECTION 5.7 CALIBRATION OF NEUTRON REM BALL

Rem ball calibrations will be performed by Ludlum Measurements or another NRC or state licensed calibration facility. A calibration sticker will be placed on the rem ball at the time of calibration. If a rem ball has not been calibrated within the past 12 months, it will be considered inoperable.

SECTION 5.8 CALIBRATION RECORDS AND DOCUMENTATION

The following calibration records will be maintained by the RSO:

1. A list of portable survey meters that are calibrated each year;
2. Calculated surface activity conversion factors (alpha and beta) calculated for each model detector commonly used for contamination surveys;
3. Proportional counter efficiencies; and
4. Calibration certificates for sources used to calibrate the high purity germanium detector. (The calibration curve is calculated by the GammaVision software and stored by the system.)

Instruments will be calibrated with the frequency below using the sources indicated.

Instrument	**Frequency**	**Source Specification**	**Geometry**
Portable survey meters	Annual	JL Shepard Calibrator	exposure
Portable survey meters	Annual	Note A	Disk
HPGe	Annual min.	Note B	Disk
HPGe	Annual min.	Note C	Marinelli -1 liter
Gas Proportional Counter	Annual	Note D	Disk
Liquid Scintillation Counter	Weekly	Note E	LSC standards
Thyroid phantom	Quarterly	Note F	Phantom standard

Note A – NIST traceable calibration standards with the 2 pi emission rate provided. Typical nuclides includes an alpha emitter such as ^{210}Po or ^{244}Cm, ^{14}C, and ^{36}Cl.
Note B – NIST traceable gamma standard with gamma energies ranging from 40 keV to 1800-2000 keV.
Note C – NIST traceable gamma standard with gamma energies ranging from 40 keV to 1800-2000 keV.
Note D- NIST traceable calibration standards with the 4 pi emission rate provided. Typical nuclides includes an alpha emitter such as ^{241}Am or ^{239}Pu and ^{36}Cl.
Note E- Packard standards.
Note F- NIST traceable ^{125}I 20 ml volume standard of ^{125}I or a 20 ml volume standard of ^{129}I (if a measured ^{125}I/^{129}I correction factor is available).

APPENDIX A SAFE LAB PRACTICES

SECTION A.1

1. Appropriate protective clothing including a lab coat, gloves, and closed toe shoes must be worn when working with unsealed radioactive sources.

2. Wash hands when leaving the work area.

3. Monitor hands and clothing for contamination at the conclusion of procedures utilizing radioactive materials or before leaving the work area. This is not required when instrumentation is not available to detect the radiation emitted by the radionuclide in use.

4. The consumption or storage of food and drink, the use of tobacco products, and the application of cosmetics are forbidden in areas where radioactive materials are used or stored.

5. Assigned personnel monitoring devices must be worn at all times in areas posted for radioactive materials use or storage. The devices must be used in accordance with this manual and the recommendations of the vendor.

6. Dispose of radioactive waste in approved containers. All radioactive waste containers must be clearly labeled as radioactive.

7. Never pipette by mouth.

8. Label all containers of radioactive materials, contaminated equipment, and contaminated work areas with radioactive materials tape or tags. Indicate the radionuclide(s) present, the activity, and the date.

9. Transport radioactive materials in strong, tight containers. Overpack radioactive liquids to prevent leakage.

10. Secure all radioactive material to prevent unauthorized use.

APPENDIX B

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APPENDIX C EMERGENCY PROCEDURES

When a spill or uncontrolled release of radioactive materials occurs, measures must be taken immediately to minimize the exposure received by radiation workers and members of the public.
The following guidelines must be followed when responding to an accident involving radioactive materials.

INITIAL RESPONSE TO A SPILL

1. Personnel protection is highest priority. If the radioactive materials are volatile, fume hood(s) must be turned on, a survey meter must be obtained, and personnel must immediately vacate the room. All doors to the room must be locked and posted to prevent entry until radiation safety personnel from the EHS Office arrive.

2. Personnel must be monitored as soon as possible with the portable survey instrument. Any contaminated clothing must be removed and placed in plastic trash bags. If skin contamination is observed, immediate decontamination must begin. Areas where monitoring or decontamination is performed must be posted and will be considered a restricted area until monitored and released by the RSO.

3. Laboratory personnel must carefully record the following information concerning the spill or release.

a. The radionuclide(s), chemical form(s), and quantity involved.
b. The time of the spill or release.
c. Personnel working in the lab.
d. Levels of contamination on personnel.

4. If only a small volume of liquid and a small quantity of radioactivity is spilled, measures to contain the spill may be undertaken. Care must be taken to avoid personnel contamination and spreading contamination to clean areas of the lab.

5. The EHS Office must be notified as soon as possible regardless of the quantity of radioactive materials involved.

6. A bioassay may be required if an uptake of radioactive material is likely.

CONTAMINATION REMOVAL TECHNIQUES

1. Personnel involved in the cleanup must wear appropriate protective clothing. Plastic or latex gloves must be worn. Rubber kitchen gloves may also be needed when cleaning floors or abrasive surfaces. If contamination on the floor is suspected, disposable shoe covers must be worn.

2. Prior to beginning decontamination all necessary supplies must be obtained including:

a. paper towels,
b. a cleaning solution appropriate for the chemical form involved,
c. a properly labeled waste container,
d. extra gloves,
e. plastic coated absorbent paper for floor contamination, and
f. a survey meter (not required with tritium).

The survey meter must be checked for proper operation and remain on for the duration of the decontamination. Areas around a contaminated floor should be covered with the absorbent paper. Absorbent paper should be used to cover the floor after cleaning until monitoring is completed by the RSO. All paper towels, disposable gloves, and absorbent paper must be placed in the radioactive waste after use.

In some cases organic solvents or corrosives may be used when decontaminating an area. Extreme caution must be used due the flammable, toxic, or corrosive properties of the compounds. Before use, the Safety Data Sheet (SDS) should be consulted. Special protective clothing, respiratory protection, and fire control equipment may be required.

3. A report by the authorized user responsible for the lab must be filed with the EHS Office within 24 hours. This report must include the following:

a. The radionuclide(s) and quantity (both volume and activity) involved,
b. The cause of the spill,
c. Decontamination efforts made by laboratory personnel before and after the arrival of radiation safety personnel to the lab,
d. The names of all personnel involved,
e. The results of survey made by lab personnel, and
f. The actions taken to prevent similar occurrences in the future.

If personnel have been contaminated, the report must also include the following information:

a. The names(s) of the persons contaminated,
b. The time the contamination occurred,
c. The radionuclides(s) and quantity of materials involved,
d. The location and size of the area of the skin involved,
e. The model and serial number of the survey instrument used,
f. The readings and time readings taken, and
g. The final results of decontamination efforts.

PERSONNEL DECONTAMINATION TECHNIQUES

When contamination of the skin occurs, immediate actions are required to safely remove the radioactivity.

1. Determine the amount of radioactivity present with a survey meter or smear.
2. Use tepid water and an appropriate soap or detergent to decontaminate. Water that is too warm or too cold can cause uptake or retention, respectively, of radioactive material in pores. A chelating agent or abrasive granules may also be used in some cases. Care must be taken minimize skin irritation. Normal hand soaps or household detergent may adequately remove the contamination. An abrasive soap or a mixture of 50% detergent/ 50% corn meal may be used when a mild abrasive is needed. Household beach may be used with some compounds.
3. Use mild decontamination techniques first. The technique selected must be suitable for the location. Strong soaps or abrasives must not be used on sensitive areas such as the neck and face. The decontamination must be performed carefully to avoid uptake of the radioactive materials into the body.
4. Contaminated hair may have to be cut if decontamination efforts fail. Extreme care must be used to avoid cuts or scrapes to the skin.
5. If open cuts or wounds are near contaminated areas, internal dose assessments may be required.
6. A log must be maintained listing the time and survey meter results (CPM) of the contaminated area. This log must include the initial readings observed when the contaminated area was first discovered.

APPENDIX D FORMS

The forms in this section are currently approved by the Committee for use on campus. These forms may be revised as needed by the Committee and may be accessed at ehs.msstate.edu.

- Application to Use Radioactive Materials
- Declaration of Pregnancy
- Exposure History Request
- MSU Radiation Safety Enrollment Form
- Radioactive Equipment Decommissioning Form

APPENDIX E PERSONNEL TRAINING PROGRAM

The following is a general summary of topics discussed during radiation safety training conducted by the Radiation Safety Officer for persons working with unsealed radioactive materials. The specific topics discussed are changed occasionally as needs change.

I. Introduction
II. Overview of Regulations, Responsibilities under MS-EBL-02
    A. Duties of the MSDH, NRC, etc.
    B. Duties of the RSO
    C. Duties of the Radiological, Chemical, and Laboratory Safety Committee
III. Procurement of Radioactive Materials at MSU
IV. Amendment process for approved users
V. Basic atomic and nuclear structure
    A. Properties of alpha, beta, and gamma radiation
    B. Shielding materials
    C. Half-life and decay equation
VI. Safety in the Laboratory
    A. Internal/external exposure
    B. Contamination control
    C. Time, distance, and shielding to minimize external exposure
    D. ALARA
VII. Personnel dosimetry
    A. Proper use of assigned dosimeters
    B. Dose limits
    C. Interpreting film badge report
    D. Annual/termination reports
VIII. Waste disposal
    A. Segregation of waste
    B. Proper labeling of waste containers
IX. Using a survey meter
    A. Basic components of a survey meter
    B. Daily survey meter checkout
    C. Troubleshooting the survey meter
    D. Limitations of the survey meter
X. Legal aspects of working with radioactive materials
    A. Inspections
    B. Consequences of noncompliance
XI. Health effects
XII. Safety video on contamination control
XIII. Written exam (70% correct to pass).

The course will either be delivered via *Canvas* using appropriate distance learning software or in a classroom setting. Annual refresher training will be provided to persons using unsealed

radioactive materials on campus. The training will be delivered either in a classroom setting or via the web. No test is required for annual refresher training.

APPENDIX F QUALIFICATIONS

Minimum qualifications for voting members of the Radiological, Chemical, and Laboratory Safety Committee, the Radiation Safety Officer, and the chairman of the Radiological, Chemical, and Laboratory Safety Committee are established in this appendix.

Voting member of the University Radiological, Chemical, and Laboratory Safety Committee

A member must be approved to use radioactive materials under MS-EBL-02 by the Committee or must be a Departmental Radiation Safety Representative.

Chair of the Radiological, Chemical, and Laboratory Safety Committee

The chair shall meet all requirements for voting members of the Committee.

The chair shall have served on the Committee for a minimum of one year prior to being appointed Chair by the Vice President for Research and Economic Development.

Radiation Safety Officer (RSO)

NRC criteria for selecting an RSO for a broad scope license can be found here:
NUREG 1556 Vol. 11 – Section 8.7.3

Educational Requirements:

Bachelor of Science degree in physics, radiation biology, radiological or nuclear engineering, health physics, or related field.

Work experience requirements:

A minimum of four years of experience in applied health physics or radiological safety in a research environment under a broad scope license.

The RSO must comply with required continuing training requirements as follows:

1. Annual HAZWOPER renewal/refresher (EPA/MS DEQ requirement).
2. Biannual (or more frequent if required by regulation) 49 CFR DOT training and IATA training for dangerous goods transportation (US DOT requirement).
3. Annual training in at least one heath physics/radiation safety-related course. At least biannually a class offering CEU credits by the American Board of Health Physics will be attended

Preferred Qualifications of the RSO:

Professional certification in comprehensive practices by the American Board of Health Physics. Professional certification by the National Registry of Radiation Protection Technologists (NRRPT).

Associate Radiation Safety Officer

Educational Requirements:

Bachelor of Science in physical sciences, health physics, radiation biology, or related field.

Work Experience Requirements:

A minimum of two years of experience in applied health physics, radiological safety in a research environment, or other related experience deemed appropriate by the RCLS Committee.

Departmental Radiation Safety Representative

Two years relevant experience using radioactive materials commonly used in the department or unit.

Completion of initial specialized training provided by the Environmental Health and Safety Office. The course will be a minimum of 6 hours and will include the following topics:

1. Contamination monitoring techniques
2. Smear analysis
3. Package receipt and monitoring
4. Reporting and record keeping
5. Emergency Procedures

Approval of his/her department head and the Radiological, Chemical, and Laboratory Safety Committee

Completion of an EHS Office annual refresher

Completion of an annual campus laboratory inter-comparison of laboratory counting equipment.

APPENDIX G

These procedures apply only to sources obtained under license MS-EBL-02 or sources obtained by MSU under a general license. These procedures will be followed when leak tests are performed by the campus RSO. If leak test kits from another source are used, then the procedures supplied with the kit will be followed.

Supplies:

Gloves
Tweezers or tongs
Paper circle
Coin envelope
Solvent such as isopropyl alcohol

Procedure:

Verify serial number of source to be checked if possible.
Don gloves.
Wipe areas surrounding the source housing carefully and completely. Use caution when the source poses a significant radiation hazard. Tongs or tweezers should be used when possible. Only the shutter and source holder rather than the source itself will be checked on extremely large sources.
Return the filter paper to the envelope.
Count the filter as required below.
Remove gloves and treat as radioactive waste if source leakage is detected.

Counting procedures:

The counting procedures that may be used will be determined based on the type(s) of emissions from the radionuclide(s) found in the source. When the radionuclide(s) has multiple nuclear emissions any suitable method listed below may be used.

Alpha emitters

Counting systems that may be used:

Gas flow proportional counter
Ludlum 2200 scaler/rate meter with model 43-9 Alpha Sample Counter

Alpha Counting Procedures

The minimum count time for sample and background is 2 minutes
Counting efficiency will be determined or estimated for the system with an alpha emitting check source.

Beta Emitters

Counting systems that may be used:

Liquid Scintillation Counter

Gas flow proportional counter

Beta Counting Procedures

The minimum count time for sample and background is 2 minutes

Counting efficiency will be determined or estimated for the system using a beta emitting check source.

Gamma Emitters

Counting systems that may be used:

NaI well detector connected to a multichannel analyzer

NaI well detector connected to the Ludlum 2200 scaler/rate meter

HPGe detector calibrated for filter papers

Gamma Counting Procedures

The minimum count time for sample and background is 2 minutes

Counting efficiency will be determined or estimated for the system using a gamma emitting check source.

Analysis of results:

The following quantities will be known:

e = detector efficiency measured or estimated

CrB = Count rate (Background) [CPM]

CrS = Count rate (wipe) [CPM]

DrN = Measured contamination rate [microcurie]

(Calculated below)

Using the above data:

$DrN = (CrS - CrB)/(2.22 \times 10^6 * e)$ microcuries

The activity may also be calculated using either ORTEC Gammavision software for the HPGe detector or the Packard software supplied with the liquid scintillation counter.

Reporting Results:

The leak test results for each source checked will be maintained on file by the RSO.