Radiation Safety Manual

Prepared by

University Radiation Safety Committee

in coordination with

Environmental Health Safety

& Risk Management

University Radiation Safety Committee
New Mexico State University
P.O. Box 30001 / MSC 3578
Las Cruces, NM 88003-8001
Tel: (575) 646-3327
Fax: (575)646-7898

RECEIVED
AUG 07 2019
By

Memorandum

August 5, 2019

To: NMSU Authorized Workers and Radiation Workers
From: Dr. Stephen Pate, Chair; University Radiation Safety Committee
Subject: NMSU Radiation Safety Manual

The information contained in the New Mexico State University (NMSU) Radiation Safety Manual was prepared by personnel in the NMSU Environmental Health Safety & Risk Management Department (EHS&RM) and has been reviewed by members of the University Radiation Safety Committee (RSC). The use of radioactive material and other sources of ionizing radiation in research and teaching activities at NMSU are regulated by federal, state and local entities. The New Mexico Environmental Department Radiation Control Bureau is the primary regulatory authority for NMSU and has issued the university a Broad Scope Type AB Radioactive Materials License and x-ray machine certificates of registration. The manual is written to partially fulfill the conditions of the license and meet the provisions of the State of New Mexico Radiation Protection Regulations (20.3 NMAC) as administered by the Radiation Control Bureau.

The RSC is composed of NMSU faculty and professional staff with expertise in a variety of areas and techniques that use radioactive material and radiation generating devices in research, clinical and teaching settings. The University Radiation Safety Officer (RSO) administers the day to day activities of the Radiation Safety Program as defined by the RSC. The use of radioactive material and radiation producing devices at NMSU must be authorized by the RSC. Both the RSC and EHS&RM are committed to supporting the teaching, research, clinical and service missions of NMSU. Radioactive materials and radiation generating devices are valuable tools in teaching and research. A primary objective of the NMSU Radiation Safety Program is to provide easy-to-follow guidance and assistance to users so we can meet our regulatory obligations and maintain a safe working environment. This manual is revised periodically so feel free to contact me or the EHS&RM RSO if you have any suggestions that you feel would benefit future editions.

The NMSU Radiation Safety Manual has been approved by the University Radiation Safety Committee and accepted by the following:

S. Pate

Dr. Stephen Pate
Chair, University Radiation Safety Committee

University Radiation Safety Committee:
Dr. Frank Ramos, Geological Sciences
Dr. Katrina Doolittle, Environmental Health Safety & Risk Management Department
Dr. Punam Thakur, Carlsbad Environmental Monitoring & Research Center
Dr. Tammara Chaffee, DACC Radiologic Technology Program
Mr. David Schoep, RSO, Environmental Health Safety & Risk Management

P.O. Box 30001/ MSC 3578, Las Cruces, NM 88003-8001 Tel: 575-646-3327 fax: 575-646-7898 safety.nmsu.edu

Table of Contents

1. INTRODUCTION

The purpose of the Radiation Safety Manual (RSM) is to describe the policies and procedures for the use of ionizing radiation at New Mexico State University (NMSU). These policies have been developed and approved by the University's Radiation Safety Committee (RSC) to ensure the use of ionizing radiation at NMSU is compliant with applicable State, Federal and local regulations as well as the conditions cited in the University's Radioactive Material License and various X-Ray Device Certificates of Registration. This manual does not address the use of nonionizing sources of radiation (i.e. laser, ultraviolet, microwave radiation).

The manual includes basic safety information for all users of ionizing radiation and other personnel who may be exposed to ionizing radiation at NMSU. It is written so that it can be used as a training aid and supplement information presented in formal staff training sessions provided by Radiation Safety Staff and Authorized Users.

Departments throughout New Mexico State University use sources of ionizing radiation. These sources include both radioactive materials and radiation-producing machines. University instructional and research laboratories routinely use radioactive materials for activities in the fields of agriculture, biology, molecular biology, chemistry, material science, medical technologies, geology, nuclear sciences and environmental science activities.

NMSU holds a Broad Scope Type AB radioactive material license and several X-Ray Device Certificates of Registration (CORs) that are issued by the New Mexico Environment Department Radiation Control Bureau (RCB). The license and CORs permit, the RSC and the Radiation Safety Officer (RSO), to authorize NMSU faculty and staff to use radioactive materials and radiation generating devices in their research, operations and teaching. Some remote NMSU facilities such as the Carlsbad Environmental Monitoring and Research Center have a facility specific license issued by the RCB. The RSC also ensures that these facilities meet the regulatory standards required for the conduct of work using radioactive material, and radiation producing devices. The RSO, employed within Environmental Health & Safety, serves as the University's compliance officer and works to ensure that all work with ionizing radiation meets the provisions of State / Federal regulations as well as RSC policies and determinations.

A successful radiation safety program depends on the cooperation of many individuals and groups at all levels within the university. This includes the University Administration, represented by the Office of Vice President for Research, the RSC, the RSO, Authorized Users and their staff / students. NMSU is committed to providing a quality radiation safety program that is designed to protect the health and safety of radiation users, the university population and the community as a whole. To meet this objective, the program incorporates personnel training; expert consultation, inspection and testing services; stringent review of procedures, facilities, and user qualifications and quick response to hazardous or emergency situations.

2. AS LOW AS REASONABLY ACHIEVABLE (ALARA)

New Mexico State University endorses and adopts the principle of keeping exposures to ionizing radiation As Low As Reasonably Achievable (ALARA). The principles of ALARA are integral to the NMSU Radiation Safety Program and every reasonable effort is made to maintain occupational exposures to ionizing radiation as far below occupational dose limits as practical.

- The University Radiation Safety Committee (RSC) uses ALARA as a governing principle when developing policies and reviewing / approving requests for use of radioactive materials and radiation producing devices.

- Formal ALARA reviews are conducted annually by the RSC to assess the effectiveness of the Radiation Safety Program and implementation of the ALARA policy.

- Occupational dose and radioactive contamination administrative control limits are established at levels well below most allowable regulatory limits and investigations are conducted when administrative control limits are exceeded.

- Procedures, processes and facilities are designed and evaluated so that exposures to workers and the general public are minimized to the greatest extent practical.

- Regular radiation safety surveillance and inspections are conducted by the Radiation Safety Officer (RSO) and EHS&RM staff to ensure that proper procedures are being used.

- Records of inspections, surveys and personnel dosimetry are maintained and regularly reviewed by the RSO to ensure radioactive contamination is controlled and employee exposures are ALARA.

The NMSU administration is committed to maintaining its radiation safety program consistent with the ALARA philosophy. The administration provides technically qualified personnel and devotes resources to ensure the university Radiation Safety Program has the tools needed to implement the ALARA policy. However, a truly successful program requires a commitment to the principles of ALARA by all persons involved in the use of radiation at the New Mexico State University whether they are administrators, faculty, researchers, staff, and ancillary personnel.

3. RESPONSIBILITIES & QUALIFICATIONS

This chapter outlines the responsibilities of the Radiation Safety Officer, the Radiation Safety Committee, Authorized Users and Radiation Workers.

Radiation Safety Officer

The Radiation Safety Officer (RSO) is qualified by training and experience in radiation protection and is available for full-time advice and assistance on radiation safety matters to the RSC, Faculty, Staff and University Administrators. The RSO is a regular position in the Environmental Health & Safety (EHS&RM) department.

RSO Responsibilities

- ❖ Maintaining University Radioactive Materials Licenses and Radiation Device Certificates of Registration.
- ❖ Serving as an official voting member of the RSC.
- ❖ Initially reviewing authorization requests to use of radioactive materials and radiation generating devices and then submitting them to the RSC for review.
- ❖ Generating Use Permits after the RSC approves an authorization request and modifying established Use Permits as needed.
- ❖ Developing various radiation safety training classes, as deemed necessary by the RSC.
- ❖ Maintaining records on radioactive material inventory, radioactive waste disposal, storage, transfers, personnel exposure, internal audits, facility surveys and other records as required by regulatory agencies.
- ❖ Being available to faculty, staff and administration for consultation on issues related to radiation safety and the safe use of radioactive material and radiation producing devices.
- ❖ Providing centralized shipping and receiving of radioactive material in accordance with State and Federal regulations.
- ❖ Keeping the Radiation Safety Manual up-to-date.
- ❖ Performing periodic reviews of occupational radiation exposures of AUs and radiation workers with particular attention to instances where administrative control limits were exceeded.
- ❖ Performing a comprehensive radiation safety program evaluation on at least an annual basis.

The RSO is authorized to:

- ❖ Issue Use Permits to RSC-approved Authorized Users approved to use radioactive material and radiation-generating devices.

- ❖ Stop any experiment or work, performed under NMSU jurisdiction, which could jeopardize the safety of property, personnel, general public or the environment. This includes activities that are not in compliance with applicable radiation protection, environmental or other government regulations.

- ❖ Seize or secure any radioactive material or radiation producing device that is being used or operated in a manner that is a flagrant violation of RSC policies, and can temporarily revoke a Use Permit.

- ❖ Verify that AUs are conducting required safety surveys and following approved procedures at facilities where radioactive materials or radiation producing devices are used or stored as required by the radiation safety program and conditions of their Use Permit.

- ❖ Approve the release of potentially radioactively contaminated areas or equipment for unrestricted use after decommissioning.

University Radiation Safety Committee

The University Radiation Safety Committee (RSC) is a group of faculty and technical staff established to advise the university administration through the Vice President for Research on radiation safety policy and programs at NMSU. The RSC is responsible setting policies and procedures for ensuring that the use of ionizing radiation at NMSU is performed safely and is in compliance with all applicable regulations governing the use of radiation and radioactive material. The RSC is also responsible for reviewing and approving all applications from faculty or staff who want to use radioactive material and radiation producing devices in research, teaching, or clinical activities.

<u>Organization</u>

The committee is representative of university departments where faculty and staff are handling radioactive material or radiation-emitting equipment using a variety of techniques. The RSO is an official member of the committee.

A minimum of three technical members are appointed to the committee by the Vice President for Research for two year renewable terms. When necessary, the Chair of the RSC makes recommendations for new members to the Vice President for Research based on nominations or recommendations of members of the RSC.

The RSC must meet at intervals not to exceed 12 months. The RSC must formally review and document the overall effectiveness of the Radiation Safety Program including the ALARA program at least annually.

New user applications may be reviewed either at a formal meeting or via e-mail communications. All written communications generated during the reviews are maintained by the RSO.

Delegation of Authority to the RSO

The RSC delegates authority to the RSO for enforcement of the Radiation Safety Program. The RSC will support the RSO when it is necessary for the RSO to assert authority. If the RSC overrules an action of the RSO, the basis for overruling the action is documented in the minutes of a meeting.

Review of New Authorization Requests

The RSC thoroughly reviews the qualifications of an applicant requesting permission to use or supervise the use of radioactive materials or radiation producing machines. The applicant's training and experience are evaluated in the context of the activity requested. A review of the types and quantities of material or device, and how the material or device will be used are conducted. The RSC reviews the applicants use protocols, administrative controls and engineering controls the applicant proposes to follow to keep exposures ALARA while conducting the requested activities. Waste streams are evaluated to minimize the generation of radioactive or mixed waste. The RSC encourages the applicant to conduct all activities with the principles of ALARA in mind at all times.

Quorums and Voting

All regular committee members including the chair and the RSO are voting members. A quorum is defined as the number of members required for business to be legally transacted. The minimum RSC members considered acceptable for a quorum are the Committee Chair, the RSO and the committee member whose field of expertise (subject matter expert-SME) is necessary to assure all safety aspects have been addressed. The RSC may also include ex-officio non-voting members who may be invited to serve when their expertise is required and they can supplement the deliberations of the RSC.

All votes, whether in a meeting or electronically, require a minimum of the Chair, the RSO and the SME. The decision of whether a vote passes or fails will be decided by a simple count of the votes of the committee members who did not abstain from voting.

Authorized Users

The faculty member, researcher or technical staff member who has received approval from the RSC to use radioactive material or devices must:

- Have the necessary training and experience to safely use, and supervise the use of, ionizing radiation. First time users may overcome a deficiency in training by working under the supervision of an experienced radioisotope user for at least 40 hours and satisfactorily completing a training course approved by the RSC.

- Ensure that all personnel who work under their Use Permit area are fully trained and qualified to perform the work and complete periodic radiation safety training as defined under the radiation safety program policies.

- Evaluate and document worker competence related to specific operational procedures.
- Ensure physical radioactive material inventories, routine radiation and contamination surveys are completed in a timely manner as required under the radiation safety program.

- ❖ Follow applicable rules, regulations, guides, and recommendations for procurement, use, possession, storage, transfer, shipping and disposition of radioactive materials.

- ❖ Make regular area surveys of their facility to assure that radioactive materials are being properly handled and confined to designated areas. Records of such surveys must be maintained for inspection by the RSO.

- ❖ Ensure that appropriate radiation survey instruments, personnel monitoring devices, PPE, engineering controls and other equipment necessary to assure worker safety while performing approved activities are available and working and used when required.

- ❖ Notify the RSO prior to making substantive changes that are outside scope of approved use of radioactive material or device such as change of location, isotopes, or new radiation producing devices.

- ❖ Notify the RSO when an AU wishes to terminate a Use Permit so the authorized area(s) and equipment can be properly decommissioned.

- ❖ Notify the RSO immediately in the event of a radiation accident (major spill, fire, contamination of atmosphere, person, or area, unauthorized release of radioactive materials, theft or loss of radioactive materials) and known or suspected overexposure of personnel to ionizing radiation in accordance with applicable regulations.

Radiation Workers

The primary goal of radiation safety activities is to avoid any unnecessary radiation exposure to workers and the general public (ALARA principle). While NMSU has a responsibility as an employer to provide a safe work environment, the primary responsibility for keeping individual radiation exposures ALARA rests with the worker. To accomplish this, workers have the responsibility to learn and follow the specific procedures and controls established by the AU when handling or using radioactive material and radiation producing devices.

4. USER AUTHORIZATION & PERMITTING

The process for obtaining authorization to work with radioactive materials, sealed radioactive sources, radioactive gases, x-ray machines or other radiation generating equipment is described below. Any person who wishes to work with ionizing radiation under at NMSU must submit a completed application (Form RS-1, Appendix A) to the RSO for initial review prior to submission to the RSC for approval. All radioactive materials or devices to be possessed must be included in the application. The acquisition and/or use of the radioactive material or radiation producing equipment must not be initiated until the application has been approved by RSC and a permit issued by the RSO.

The use of source material initially obtained in concentrations below 500 ppm does not require approval from the RSC since it is below the licensing limit. However, the waste generated from the use of this material may require special handling; therefore, the RSO must be notified whenever source materials are used. The RSO will provide the researcher with specific requirements for working with sand disposing of source material.

Application for Use of Ionizing Radiation

The "Application for Use of Ionizing Radiation" (Form RS-1 in Appendix A) is a multi-purpose application used by the RSC to review requests to use all types of ionizing radiation, radioactive materials and radiation producing devices. Some sections of the application are required to be completed no matter what type of use while other sections are specific to the type of material or device.

General Instructions for Completing Application Form RS-1

Section 1, 2 and 3. Applicant information, training and experience **(all application types)**

Section 4. List the maximum possession limit desired (this includes any waste that may be accumulated in the lab), identify the material by chemical composition **(Un-encapsulated radioactive materials applications)**

Section 5. List maximum possession limit desired for each sealed source. Identify each sealed source by manufacturer, model number, NMSU equipment property number and activity of each isotope. Physical forms for sealed sources can be capsule, rod, foil in ECD, etc. listed in the table. **(Sealed Radioactive Source applications)**

Section 6. List all x-ray generating machines or devices including their types, specifications, date manufactured, date to be installed and other information requested in the table. **(X-ray and other radiation producing machines applications).**

Section 7. List the lab or other location of proposed use. **(All application types)**

Section 8. Describe the purpose for which the radioactive material, sealed source or x-ray machine will be used. A short paragraph describing the experimental protocols including estimates of the quantity of radioactivity which will be utilized in each experiment, estimated frequency of use and other information which provides an estimate of typical use of radioactive materials. Identify any field use of radioactive materials or equipment, including animals or plant test systems. Identify any toxic, flammable, and other hazardous characteristics involved with the radioactive materials, including biohazardous or other regulated chemicals. **(All application types; tailor type of information provided as needed)**

Section 9. Describe facilities and equipment including any engineering controls such as fume hood or shielding and waste storage facilities. Give a statement of material security controls such as locking storage cabinets and laboratory security protocols when personnel are not present. **(All application types; tailor type of information provided as needed)**

Section 10. Describe precautionary methods that will be employed to prevent contamination of personnel and uncontrolled areas including type and frequency of contamination surveys, type and location of available survey instruments (portable or other counters) and other lab-specific safety practices (refer to the Radiation Safety Manual for a list of standard practices). Identify whether occupational radiation exposure monitoring for personnel is required or provide dose calculations that show it is not necessary. Describe the extent of instruction to be conducted for users under the requester's supervision. Training is required as set forth in Chapter 5 and includes Radiation Safety training offered by EHS&RM and specific instruction provided by the AU. **(All application types; tailor type of information provided as needed)**

Section 11. Describe potential types of waste (aqueous, liquid scintillation fluids, lead pigs, solid lab trash, polyacrylamide gels, etc.) that will be generated including any special or mixed (chemical or biological) waste products. Provide typical estimated quantities, concentrations and estimated volumes for each isotope and/or waste stream. For sewer disposal of aqueous wastes, show that the waste will meet the criteria for disposal via sanitary sewer and is not otherwise hazardous. If approved, a sewer disposal authorization note will be attached to the permit. Transfer or disposal of sealed sources, x-ray machines and other radiation producing devices must go through the RSO prior to final disposition. **(All application types; tailor type of information provided as needed)**

Section 12. Shipping and receiving of radioactive material x-ray machines and other radiation producing devices must go through the RSO. State if any shipping of radioactive material or devices is expected. Identify the procurement method you will use to obtain radioisotopes, sources or equipment. **(all application types)**

Section 13. Provide other information pertaining to the operation which will ensure that the program will be conducted in a safe manner with exposures ALARA and in compliance with pertinent rules and regulations. **(all application types)**

Additional Instructions for Special Types of Applications

Nuclear Gauges and Other Large Sealed Sources

Applicable sections of the Form RS-1 application must be completed to receive RSC approval to use sealed radioactive sources. The application must include sufficient information to determine that the proposed use will be in compliance with applicable regulations. The application must include the proposed use, any special handling techniques and/or remote handling tools needed to manipulate the source and the location(s) the source will be used and stored. Of the source will be used at field locations a description of the type of operations, locations and specific procedures for the use, security and control of the source must be included. A description of the source storage facilities, anticipated radiation levels within the storage area and any special shielding or facility design requirements meant to reduce radiation levels should also be included in the application. Many sealed sources must be leak tested periodically. The application should state any leak test requirements and the means for meeting the requirement. If the source is exempt from leak testing this must be specifically stated in the application. A description of the type and frequency of user training must also be specified. This information may be found in applicable sections of this manual.

Large Quantities of Unsealed Radioactive Materials

In addition to the other information needed in the Form RS-1 application, proposals to use large quantities of unsealed radioactive materials will be specifically evaluated for the potential to release material in effluents (air, water, sewer, etc.) to unrestricted areas. The engineering & administrative control procedures needed to control the release of large amounts of radioisotopes to unrestricted areas must be included in the application. If the type of experiment and the quantities of radioisotopes to be used are such that significant quantities of radioisotopes may be dispersed to the air or water the applicant must show calculations that concentrations potentially released during the experiments will not exceed allowable release limits for the isotope(s) being used.

Radioactive Gases or Volatile Forms of Radioactive Material

In addition to the general requirements on Form RS-1, calculations for any releases (planned or unexpected) and the type of air monitoring or sampling to be employed must be described. Emergency procedures or specific steps relative to the particular operation and availability of engineering controls, such as exhaust hoods, glove boxes, HEPA or charcoal filters, etc. must be described.

X-Ray Devices or other Radiation Emitting Machines

X-ray generating equipment that requires RSC approval and permitting to operate include, but are not limited to, the following types of devices:

- Medical diagnostic x-ray machines including radiographic, therapeutic, fluoroscopic and dental x-ray units.
- X-ray diffraction systems.
- X-ray fluorescence systems.
- Electron microscopes.

Faculty and staff that wish to use these types of devices are required to complete the applicable sections of the RSC Application to Use Radioactive Material or Radiation Producing Devices and submit it to the RSO for review and submission to the RSC. Once this type of application has been approved by RSC and the RSO has issued a permit, the RSO will register the x-ray machines with the New Mexico Environment Department Radiation Control Bureau. A Certificate of Registration from the RCB must be received by the RSO prior to use of the radiation machine.

The RSC will review all applications as expeditiously as possible; however, registration with NMED may extend the process. About two months should be anticipated for approval and the NMED Certificate of Registration to be received. In addition, the removal, transfer or relocation of radiation machines is a regulated activity and must be coordinated through the RSO to ensure compliance with NMED regulations.

Applications will be evaluated by the RSC based on the application information pertaining to radiological safety, such as personnel monitoring and area monitoring, specific techniques to be employed and other aspects of the program related to RSC policy and RCB regulations. The RSC will evaluate the adequacy of the training and experience of personnel requesting permission to use or supervise the use of x-ray generating devices in the context of the plans for use. The RS-1 should include:

- Specific description of equipment to be used.
- Description of the techniques or measurement protocols.
- Exposure control methods to be employed.
- Personnel dosimetry and exposure monitoring that will be used.
- Location where the equipment will be used.
- Description of how the equipment and area will be secured and methods to prevent unauthorized use.
- Dose rate surveys will need to be conducted to determine personnel and area radiation exposure levels.
- Depending on the outcome of the survey, specific construction design criteria or special shielding requirements may need to be used.
- If specific training or certifications have been completed they should be forwarded with the application.

When approved by the RSC, the RSO will issue a permit to the applicant for a period of time not to exceed the expiration of the NMED Certificate if Registration for the machine.

<u>X-Ray Generating Devices That Don't Require RSC Approval or Permitting</u>

Potential sources of x-rays that do not require licensing or permitting because they are not regulated include a wide variety of high-voltage gaseous discharge and electronic tubes. At voltages below 10 kV, the inherent shielding provided by the tube wall is generally sufficient for attenuation of the x-radiation to an acceptable level. Types of devices which may emit x-rays as a byproduct but are not regulated include:

- High-voltage projection systems (older television sets).

- High power amplifying tubes, such as klystrons and magnetrons used for production of intense microwave fields.
- Transmitting tubes, such as are found in commercial radio transmitters.
- High voltage rectifier tubes, such as used in power supplies.
- Discharge tubes in which the gas pressure may be varied while studying electrical discharge.

Application Submission and RSC Evaluation Process

Each application request must be forwarded in writing to the RSO on Form RS-1. This form should also be submitted electronically to expedite review. Please allow <u>at least one month</u> for the evaluation and approval process. The RSC will review all applications as expeditiously as possible; however, the RSO may find it necessary or desirable to discuss items in the proposal with the applicant, visit the site or facility, and make recommendations to the applicant prior to review by the RSC.

Applications will be evaluated in regard to statements made pertaining to radiological safety, such as personnel monitoring, contamination surveys and control records, disposal, storage, techniques to be employed, and other aspects of the program related to University policies and the University Radioactive Material License. The RSC will evaluate the adequacy of the training and experience of applicant and other personnel to use or supervise the use of ionizing radiation in the context of the proposed work.

The RSO will respond to the applicant in writing regarding the RSC's approval, denial or conditional approval with special limitations or conditions.

When the application is approved, a permit (applicable version of Form RS-2) is issued to the applicant by the RSO. The permit includes information on the authorized type and maximum amounts of material an applicant may use or possess. The permit also provides applicable specific rules or stipulations set forth by the RSC when the application was approved.

Permits to use or possess radioactive material under this license are issued for periods of time at the discretion of the RSO, but not to exceed the expiration of the NMSU Radioactive Materials License in effect when the permit was issued. For example, in the event an applicant is conducting a radioisotope program or research for one school term, the permit will be issued for the school term; whereas, a continuing program may have a permit issued for several years

Permit Modification, Inactivation or Termination

<u>Permit Modifications</u>

When an authorized user wishes to modify their permit, Form RS-1A should be filled out and submitted to the RSO at least 10 days prior to the implementation of the change. The RSO may amend established permits as necessary to accommodate minor changes in research programs or to reflect current inventory.

<u>Inactivating a Permit</u>

Inactive AUs are those who maintain a radioactive material permit, but have had no inventory in use, storage, or waste stream for a least one year. An active user who wishes to be placed on inactive status must request this in writing. If agreed, the RSO will then list the AU as inactive.

The inactive AU must notify the RSO in writing once a year of their continuous inactive status.

To reactivate a permit the AU must notify the RSO in writing and request that the permit be re-activated. The permit be reactivated before procuring new material or beginning to use materials or a device again. Once active, the AU will again take on all user responsibilities.

Permit Termination, Lab Decommissioning & Unconditional Release

When an AU wishes to terminates a permit they are required to follow the EHS&RM Laboratory Decommissioning Procedure (download from EHS&RM web site) prior to vacating a laboratory or other space where chemical, biological, or radioactive material have been used or stored. The decommissioning process must be followed when:

- Terminating affiliation with NMSU.
- Relocating to another lab.
- Major laboratory renovation.
- Retirement.

Authorized User Responsibilities

- Notify the RSO in writing when a Radioactive Materials, Sealed Source, or X-ray Permit is no longer needed. Useable stock materials may be transferred internally to another AU with prior approval of the RSO.

- Dispose of all radioactive waste, unwanted stock materials or sealed sources through the RSO.

- Clean all areas where radioactive materials or waste were used and stored.

- Notify RSO and schedule a decommissioning survey to be performed by the RSO.

- Transfer the following records to RSO:
  - *Worker exposure records* **-**All actions followed to reduce the contamination of a worker, including name of person surveyed, description of incident with prior work activity, probable cause and steps taken to reduce future incidence of contamination, times, dates, and the surveyor's name and signature.

  - *Facility contamination records* **-** Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment or site. Limit records to instances when contamination remains after cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in porous materials such as concrete. Records should include any known information or identification of involved nuclides, quantities, forms and concentrations.
  - *Radiation Safety Manual*

- Remove all radiation symbols and signs upon release of area by RSO.

Department Head Responsibilities

- ❖ Ensure that decommissioning policy and release procedure is followed by the AU (Faculty or permitted employee under Department's supervision).

- ❖ Sign applicable decommissioning documentation signifying that the decommissioning has been completed.

RSO Responsibilities

- ❖ Properly dispose of all residual radioactive materials and waste.

- ❖ Perform release survey in cooperation with the AU.

- ❖ Maintain documentation as required regarding personnel monitoring, facilities contamination and radioactive material disposition.

- ❖ Issue a letter stating that the facility is released for unrestricted use.

<u>Failure to Properly Modify / Terminate a Use Permit or Decommission a Laboratory</u>

The AU's supervisor and department will assume responsibility including any associated costs of terminating a use permit including decommissioning a laboratory if an AU fails to follow RSC procedures.

If an AU is relocating rather than terminating a permit but fails to follow the proper permit modification and lab decommissioning procedures, their use permit may be suspended or revoked by the RSC after review.

5. TRAINING

The Radiation Safety Manual is designed to supplement the formal training sessions provided EH&S and the AU. The AU is responsible for ensuring all workers authorized to use radioactive material or radiation-producing devices under their permit have met all applicable training requirements. Environmental Health & Safety maintains records of training formal safety provided employees.

Requirements for Authorization Users

An AU's qualifications and training are reviewed and must be approved by RSC as part of the initial authorization process. In general, the minimum training and experience requirements for AUs requesting to use open radioactive materials are:

- ❖ A college degree at the bachelor level, or equivalent training and experience, in the physical or biological sciences or in engineering; and

- ❖ At least 40 hours of training and experience in the safe handling of radioactive materials, and in the characteristics of ionizing radiation, units of radiation dose and quantities, radiation detection instrumentation, and biological hazards of exposure to radiation appropriate to the type and forms of material to be used.

The requirements above are for users which use radioactive materials in microcurie to low millicurie quantities. Additional training may be required by RSC for high-toxicity materials, highly reactive materials or unusual uses.

Training offered by the manufacturer or equivalent training may be required by the RSC for AUs that are requesting to use devices such as nuclear gauges or specialized x-ray systems.

At a minimum, all new AUs are required to complete orientation training with the RSO designed to acquaint new AUs with the NMSU Radiation Safety Program and RSO. This training is required for all new AUs.

Periodic refresher training is also required for AUs authorized to use open source materials (usually an annual refresher) or portable nuclear gauges (3 year DOT HazMat Transportation refresher).

Requirements for Radiation Workers

Individuals handling radioactive material under the authorization of an AU supervision of an approved AU must receive appropriate initial Radiation Safety Training provided by EHS&RM.

Worker radiation safety training includes, at a minimum, the following information:

- ❖ Procedures for storage, transfer or use of radiation and/or radioactive material;

- ❖ Instruction in the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure and in the purposes and functions of protective devices employed;

- ❖ Instruction in, and required to observe, to the extent within the workers control, the applicable regulations and license conditions for the protection of personnel from exposure to radiation and/or radioactive material;

- ❖ Instruction of their responsibility to report promptly to RSO or AU any condition which may lead to or cause a violation of regulations and licenses or unnecessary exposure to radiation and/or radioactive material;

- ❖ Instruction in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation and/or radioactive material;

- ❖ Instruction on how to obtain worker radiation exposure reports if the worker is required to me monitored.

Per 20.3.10 NMAC *Notices, Instructions and Reports to Workers: Inspections*, all individuals who in the course of employment at NMSU are likely to receive in a year an occupational dose in excess of 100 mrem (1 mSv) are required to receive this training.

In addition to training provided by EHS&RM, the AU must also provide practical, lab-specific training for all individuals prior to beginning work with radioactive materials. The AU is to work directly with new workers until the AU is confident in the worker's abilities to perform their assigned tasks unsupervised. All workers under AU's supervision must be instructed in specific work techniques, chemical, radiological and physical hazards of the materials the worker will be handling and appropriate lab-specific emergency procedures. The AU must document that a worker has completed all required training and certify that the worker is competent and qualified to perform the work.

- ❖ Periodic refresher training, usually annually, is required for all workers handling radioactive materials.

Requirements for X-ray Device Operators

Analytical X-Ray Device Training

Training requirements for analytical x-ray device operators are described in 20.3.8 NMAC *Radiation Safety Requirements for Analytical X-Ray Equipment*. The Analytical X-ray Safety training class offered by EH&S in conjunction with required system-specific training that must be provided by the AU is designed to meet these requirements and is required training for all operators. Analytical x-ray operator training includes at a minimum:

- ❖ Identification of radiation hazards associated with the use of the equipment;

- ❖ Significance of the various radiation warning and safety devices incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;

- ❖ Proper operating procedures for the equipment;

- ❖ Recognition of symptoms of an acute localized exposure; and

- ❖ Proper procedures for reporting an actual or suspected exposure.

Before being allowed to operate the device unsupervised the operator must demonstrate competence in safely operating the device. The device-specific training must be documented by the AU and the AU must certify in writing that the worker has completed all required training and is competent to operate the device. In some situations training provided by a device manufacturer may be accepted as equivalent training in lieu of NMSU training. Equivalent training must be approved by the RSO or as part of the initial RSC authorization.

- ❖ For fixed x-ray systems, retraining is required whenever the system components or built-in safety devices are significantly modified or approved operational procedures are changed.

- ❖ Portable, handheld x-ray users must complete refresher training annually including reviewing the safety sections of the user manual for their unit.

<u>Medical / Dental X-Ray Device Operator Training</u>
Operators of medical or dental x-ray devices must be a licensed healthcare provider with certified ancillary training, or a state registered technologist. These requirements are described in applicable chapters under the NMAC Title 16 Occupational and Professional Licensing or 20.3.20 NMAC Radiologic Technology Certification, as appropriate.

Portable, handheld x-ray operators must complete appropriate manufacturer provided training annually.

Requirements for Portable Nuclear Gauge Users
An AU must take first-time equipment specific training from the manufacturer of the nuclear gauge or other training approved in writing by the RSC or RSO. Staff or students may attend EHS&RM Radiation Safety for Nuclear Gauge Users to fulfill their initial training requirement or a similar course from the gauge manufacturer. Anyone transporting a nuclear gauge falls under the Department of Transportation requirements of 49 CFR 172 regarding hazardous materials transportation. Under 49 CFR 172, DOT HazMat refresher training, specific to transportation of nuclear gauges, is required at least every 3 years. EHS&RM offers a refresher training designed to meet the DOT requirements for transportation of portable nuclear gauges.

Requirements for Ancillary Staff
Environmental Health Safety & Risk Management has developed a comprehensive training program to instruct each different group of workers e.g., technical radiation safety staff, student researchers, waste handlers, animal caretakers, and ancillary staff (janitorial, housekeeping,

security, etc.) with appropriate information to understand the hazards associated with their work and appropriate actions to prevent unnecessary exposure. The appropriate radiation safety information is incorporated into the Employee Safety and Hazard Communication general safety orientation, Hazardous Waste Management training, Basic Radiation Safety and Nuclear Gauge Radiation Safety courses provided by EHS&RM.

Performance-Based Training Requirement

In all types of training, in addition to any general training provided by EHS&RM, it is recommended that there be an emphasis on performance-based (on-the-job) training, i.e., "hands-on" training specific to the individual's duties, to ensure safe handling of radioactive materials in accordance with the ALARA philosophy. The instruction and documentation of job specific training is the responsibility of the AU. The comprehension and abilities of radiation workers will be assessed through random interviews with AUs and their radiation workers as part of the radiation safety audit and laboratory inspection process conducted by Radiation Safety program staff.

Authorized User and Radiation Worker Training Records

NMSU EHS&RM maintains records of safety training completed by AUs and their workers. However, AUs are also responsible for maintaining training documentation for themselves and all workers performing work under their permit. Training record verification is included as a part of periodic inspections and surveillances conducted by EHS&RM Radiation Safety staff.

6. OCCUPATIONAL EXPOSURE AND PERSONNEL MONITORING

Radiation Exposure Risks

Exposure may be received from radioactive materials which are external to the body (external exposure) or from radioactive materials which are inside the body (internal exposure) or both. Since any radiation dose is assumed to increase the risk of health effects in the exposed individual, all radiation doses should be minimized to the extent that is practical. Furthermore, no exposure is warranted unless there is an expectation that the activity will yield a benefit which exceeds the risk (ALARA principle).

While NMSU has a responsibility as an employer to provide a safe work environment, the primary responsibility for keeping an individual's radiation dose as low as reasonably achievable (ALARA) rests with that individual.

Radiation Dose Limits

The RCB regulatory limits for occupational exposures from ionizing radiation are defined in 20.3.4 NMAC *Standards for Protection against Radiation*. Table 6.1 provides a summary of these limits.

NMSU Occupational Radiation Exposure Limits

The NMSU RSC has set an administrative dose limit of 10 percent of the RCB dose limits (Table 6.2) for all authorized workers working with radioactive materials or radiation producing devices. The administrative control limits are a central part of the NMSU Radiation Safety ALARA program. Historical monitoring data demonstrate that the majority of NMSU occupational doses are maintained well below both regulatory and the NMSU administrative dose limits.

All work with radioactive materials or radiation producing devices must be conducted in a manner such that no individual receives a dose exceeding the NMSU administrative control limits in Table 6.2. Occupational exposures in excess of the administrative dose limit will result in an investigation by RSO. Information on the risks from exposure to ionizing radiation can be found in NRC Regulatory Guide 8.29 *Instructions Concerning Risks from Occupational Radiation Exposure*.

General Public Radiation Exposure Limits

All work with radioactive material or radiation-producing devices must be conducted in such a manner that no member of the general public can receive a dose in excess of 100 mrem in one year or in excess of 2 mrem in any one hour.

Minor (under 18 years old) Radiation Exposure Limits

Anyone under 18 years of age must not receive any exposure that exceeds one tenth of the limits for adult workers. NMSU does not allow anyone under the age of 18 to work with radioactive sources or radiation producing devices without prior written approval from the RSO.

Table 6.1 State of New Mexico / Federal Occupational Dose Limits (20.3.4 NMAC)	
	mrem / year
Total Effective Dose Equivalent (Whole Body)	5000
Shallow Dose Equivalent (Skin) or Extremity	50,000
Committed Dose Equivalent to any Organ	50,000
Eye Dose Equivalent	15,000

Table 6.2 NMSU Administrative Control Dose Limits			
	mrem / year	**mrem / quarter**	**mrem / month**
Total Effective Dose Equivalent (Whole Body)	500	125	40
Shallow Dose Equivalent (Skin) or Extremity	5000	1250	400
Committed Dose Equivalent to any Organ	5000	1250	400
Eye Dose Equivalent	1500	375	125

Personnel Monitoring

NMSU uses several monitoring methods to evaluate worker exposures to ionizing radiation. It is important to note that any type of personnel monitor only records the amount of exposure received and does not protect the wearer from radiation and associated effects. Personnel dosimetry monitoring is used to document that an individual's exposure to ionizing radiation is below established regulatory and administrative dose limits over a specific time period. This chapter discusses dose limits, conditions under which monitoring for internal and external exposures should occur and several methods that can be used for monitoring.

The AU must provide dosimetry to users whenever it is required and must ensure that the RSO receives a copy of all personnel monitoring reports. Most dosimetry vendors will send a duplicate copy to the RSO if requested by the AU. The RSO maintains the official dosimetry records for NMSU workers.

Both internal and external monitoring can be used to assess worker exposure to ionizing radiation. External dosimetry deals with radiation that originates outside the body. For example, an external dosimeter is typically worn by a worker to measure the external dose received by a worker exposed to due to photons emanating from a Co-60 source or x-ray machine. Internal monitoring is used to calculate the committed effective dose equivalent (CEDE) a worker will receive from radioactive material taken into the body. An example is the calculation of the CEDE a worker will receive after they accidently ingested I-125 while working in a lab.

External Dosimetry

Due to the wide variety of ways radioactive material and radiation producing devices are used at NMSU, there is no "typical" or "average" exposure that has any meaning. Most individuals working with radiation sources are not expected to receive doses that are not appreciably above background levels and do not require personnel monitoring devices. However, in certain circumstances or when working with certain types of radioactive materials or radiation producing devices dosimetry is required. This section describes when external dosimetry is required to be worn by workers.

External Whole-Body Monitoring Criteria

Individuals whose external dose may exceed 10% of the applicable annual limit are monitored on a monthly or quarterly basis to ensure that doses are kept ALARA. Personnel using x-ray machines or workers who routinely use isotopes which emit high energy beta, gamma or neutron radiations (i.e. P-32, Ca-45, I-125, Cs-137, Am-241:Be, Co-60) may be required to be monitored if it is likely they could exceed a NMSU administrative dose limit. Monitoring for external exposure is required when:

- ❖ By process knowledge or through calculation it is likely a worker will exceed an NMSU Administrative Control limit listed in Table 6.2.

- ❖ A worker will enter a high (> 100 mrem/hour) or very high radiation area (>100 mrem/hour).

- ❖ A worker provides the RSO a written Declaration of Pregnancy.

Extremity Monitoring Criteria

Extremity monitoring (e.g. finger ring TLD badges) may be required when a worker is using certain radioisotopes in the amounts listed in this section or when they are working with an open beam x-ray where extremity exposure may exceed an NMSU administrative control limit. This includes workers who routinely handle:

- ❖ More than 2 mCi of any gamma or a beta-emitter with a maximum beta energy greater than 250 keV.

Finger or wrist dosimeters must also be worn by x-ray operators who are:

- ❖ Using x-ray systems having an open-beam configuration that are not equipped with a safety device which prevents the entry of any portion of the worker's extremity into the primary x-ray beam or which causes the beam to be shut off upon entry into its path.

- ❖ Maintaining x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.

Extremity monitoring may be required for individuals who are working with amounts less than those listed above if the RSC review of the proposed operation indicates that the monitoring is prudent based on how the material will be handled. Furthermore, if an employee feels that they need a dosimeter when one is not specifically required as part of the RSC authorization they should contact the RSO.

Types of External Dosimeters

The most common type of dosimeter used to measure whole body external dose equivalent is an Optically Stimulated Luminescence (OSL) badge. Extremity monitoring is typically done using a small thermoluminescent dosimeter (TLD) ring badge.

Optically Stimulated Luminescence (OSL) – These badges are used to monitor medium to high energy beta, gamma, x-ray and neutron radiations. All dosimeters should be protected from the effects of heat and moisture. Personnel utilizing x-ray machines or isotopes are required to wear OSL for personnel monitoring if they may receive a dose in excess of the administrative dose limits. At NMSU, dosimeters are commonly used when personnel work with isotopes which emit high energy beta, gamma or neutron radiations (^{32}P, ^{45}Ca, ^{125}I, ^{137}Cs, ^{241}Am:Be, ^{60}Co ^{238}U).

Finger Badges - These small thermoluminescent dosimeter (TLD) badges are designed to be worn on the finger or wrist to record dose to the hands. They are sensitive to gamma, x-ray and high energy beta. Primary users include those handling millicurie quantities of ^{32}P or working with open beam x-ray machines.

Wearing an External Dosimeter

Deep-Dose Equivalent – measured at a tissue equivalent depth of 1 cm. This is a whole body dose. In order to measure the deep-dose equivalent, dosimeters are worn on the front of the body between the shoulders and the waist on the outer most piece of clothing.

Shallow-Dose Equivalent – measured at tissue equivalent depth of 0.007 cm. This is a skin dose or an extremity dose. Ring (finger) dosimeters are often used to measure the dose to extremities.

Eye-Dose Equivalent – measured at tissue equivalent depth of 0.3 cm of the eye. The whole body dosimeter is used and the dosimeter should be placed at the collar. This is a reasonable location to measure both the eye and whole body dose.

Alternate locations for dosimetry may be necessary for some employees. An example is the use of lead aprons. In this case, two dosimeters may be issued to a declared pregnant worker, one to be worn under the apron to measure dose to a fetus for a pregnant employee, and the other worn on the outside of the apron between the neck and waist to measure the potential dose received by the mother.

General Rules for Using an External Dosimeter

- ❖ Always wear your own personal dosimeter. Never allow another person to wear a dosimeter issued to you and never wear a dosimeter assigned to another individual. The function of a dosimeter is to legally document the radiation dose an **individual** received from working with radioactive material or a radiation producing device.

- ❖ Wear whole body dosimeters between the shoulders and waist with the name facing out.

- Store your dosimeter at work in a safe place (e.g., your desk) away from all sources of ionizing radiation.

- Do not get your dosimeter wet or subject it to extreme heat or cold for extended periods of time.

- In the event that your dosimeter is lost or damaged, immediately notify your supervisor (AU) to arrange for replacement. No work with radiation should take place until the dosimeter is replaced.

- Remember that most types of external dosimeters will not provide any type warning when an individual receives a radiation dose. They do not change color, beep, or in any other way visually indicate exposure has been received. Their sole function is to legally document the radiation dose an individual received from working with radioactive material or a radiation producing device.

- Do not take your dosimeter with you when undergoing any type of medical or dental radiographic or nuclear medical procedure. Dosimeters are intended to measure doses received while at work.

External Dosimetry Report Notifications

AUs and the affected worker will be notified by the RSO when a whole-body or extremity dosimeter reading exceeds an administrative control limit. During this notification, an inquiry will be made by the RSO and AU to determine if techniques or devices are available that could reduce exposures in the future.

Internal Dosimetry

The use of unsealed or volatile radioactive material increases the potential that a worker could get radioactive material inside their body (i.e. inhalation, ingestion, absorption). A bioassay can be used to determine the kinds, quantities or concentrations, and in some cases, the locations of radioactive material in the body. The results of the bioassay are then used to calculate the worker's committed effective dose equivalent from the intake. Bioassays can be separated into two types:

- Direct measurement bioassay - external measurement of radiation emanating from the body. Examples would be the direct measurement radioiodine in the thyroid using a NaI scintillation detector placed on the neck of a worker or the direct measurement of gamma emitting radionuclides in the body by placing High-purity Germanium (HPGe) detectors over a worker's body and doing gamma spectroscopy.

- Indirect measurement bioassay - measurement of radioactivity in body excreta, such as urine, feces, saliva hair or blood then analyzing the sample in a laboratory for the radionuclides of interest. Indirect bioassays are frequently used to monitor workers using large quantities of many of the common types radionuclides used in university laboratories.

Radiobioassay Monitoring Criteria

Radiobioassay monitoring is required for personnel using radioactive material in excess of quantities shown in Table 6.3 if they are handling volatile forms of uncontained (unsealed) radioactive materials. The activity can be increased by a factor of 10 if the process is performed in a certified fume hood and can be increased by a factor of 100 if the process is performed in a glove box. When non-volatile forms of the radionuclide are used, the limits can also be increased by a factor of 10 before a bioassay is required. Individuals working with activities less than the required levels shown, but have a concern about a possible uptake, should contact the RSO for counseling or testing.

It is important to note that "working with" includes withdrawing any amount of material from a stock solution containing an activity equal to or greater than the specified amounts listed, even though the activity to be used in the experiment is below the levels which warrant bioassay.

Table 6.3 Required Radiobioassay Limit for Selected Radioisotopes

Radioisotope	**Activity Handled** (Unsealed Volatile Forms)
Iodine-125	0.1 mCi
Hydrogen-3	10 mCi
Sulfur-35	1 mCi
Carbon-14	1 mCi
Phosphorus-32	1 mCi
Calcium – 45	0.1 mCi

Note The activity limits requiring bioassay can be increased by a factor of 10 if the process is contained in a certified fume hood and can be increased by a factor of 100 if the process is contained in a glove box. When nonvolatile forms of the radionuclide are used, the limits can also be increased by a factor of 10 before a bioassay is required.

If monitoring indicates an internal intake over an NMSU Administrative Control Limit, the RSO will contact the AU to determine the cause of the intake and what corrective actions are necessary to avoid additional intakes. If monitoring indicates an intake in excess of 25 percent of the limits, then the AU must submit a written report to the RSO explaining the circumstances surrounding the intake. Specific procedures for performing radioiodine and tritium (H-3) bioassays are outlined below.

Radioiodine and Tritium Bioassay Procedures

Radioiodine Bioassays

Personnel using radioiodine in excess of the quantities listed in Table 6.4 are subject to bioassay monitoring. Required thyroid bioassays should be conducted not sooner than 24 hours, but within three days of use of radioiodine.

Table 6.4 Required Bioassay Limits for Radioiodine Use

Location of Operation	Volatile or Dispersible Forms	Bound, Non-Volatile Forms
Bench Top	0.1 mCi	1 mCi
Chemical Fume Hood	1 mCi	10 mCi
Glove Box Or Mini-Hood With a Charcoal Filter	10 mCi	100 mCi

Individuals working with a total amount of activity over a five-day period that is equal or greater than the limits in Table 6.4 limits are also subject to thyroid monitoring.

The RSC must review and approve procedures and instrumentation that is used to perform thyroid monitoring. A NaI detector with a thin window attached to a rate meter or scaler is typically adequate for thyroid bioassay measurements. Any instrument that is used to monitor an individual's thyroid, as part of a radioiodine bioassay program, must be calibrated annually. In addition, the counting efficiency must be determined using a thyroid phantom standard. The equipment used for radioiodine bioassay must be capable of detecting at least 10 nanocuries (nCi) radioiodine in the thyroid.

If a thyroid burden of an individual exceeds 60 nanocuries (nCi), the AU shall notify the RSO in writing. If the thyroid burden exceeds 120 nCi, the RSO will investigate the cause of the intake and work with the AU to identity and implement ways to reduce future intakes.

Tritium Bioassays

Personnel using H-3 in excess of the quantities listed in Table 6.5 are subject to urine bioassay monitoring beginning no sooner than 24 hours, but within three days of use.

Table 6.5 Required Bioassay Limits for Tritium Use

Location of Operation	Tritiated Water and Tritiated Compounds
Open room on bench top	100 mCi
Chemical fume hood	100 mCi

Glove box or mini-hood with charcoal filter	1 Ci

Limits are at or below the limits cited in NRC Regulatory Guide 8.32 *Criteria for Establishing a Tritium Bioassay Program*

The RSC will review and approve sampling procedures and analytical laboratories used to perform urine bioassay for tritium. The analytical methodology used must be able to detect 0.3 microcuries per liter (µCi/L) or less in urine. The RSO will provide the individual the urine collection kits and instructions for use.

If the bioassay analysis shows H-3 concentrations exceeding 0.0002 µCi/ml, the individual monitored and their AU will be notified by the RSO. If the H-3 concentration exceeds 0.0006 µCi/ml, the RSO will investigate the cause of the intake and work with the AU to identify and implement exposure reduction actions.

Prenatal Radiation Exposure & Declaring a Pregnancy

Many scientific studies have demonstrated that cells are more sensitive to ionizing radiation damage when they rapidly divide and are relatively unspecialized in their function. Therefore, children are more sensitive to radiation than adults and an embryo or fetus is more sensitive than children, especially during the first trimester.

This principle of increased sensitivity has long been a factor in the development of radiation dose limits. Because the risk of harmful effects from radiation may be greater for young people, dose limits for minors are lower than for adult workers.

When a woman is pregnant and her abdomen exposed to radiation, the embryo / fetus may also be exposed. Many times a woman may not know that she is pregnant during the critical first 3 months of her pregnancy. Since it is very important to minimize the exposure of the embryo / fetus to ionizing radiation, the dose limit for a declared pregnant woman is set at **500 mrem for the entire gestation period.** In addition, to avoid spikes in the exposure a dose limit of **50 mrem / month** has been established. For additional information on risks refer to NRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* .

It is the responsibility of the mother to decide whether the risks to a known or potential unborn child are acceptable. The NRC Regulatory Guide 8.13 recommends that the mother consider the following facts:

- ❖ The first three months of pregnancy are the most important, so the decision to declare a pregnancy should be made early. A special ALARA evaluation and monitoring can begin as soon as a pregnancy is declared.

- ❖ In most work situations, the actual dose received by an unborn child will be less than the dose to the mother, because of shielding provided by the mother's body.

- The dose of the unborn child can be reduced by reducing the amount of time exposed to the source of the radiation, increasing the distance of the mother from the source of radiation, and shielding the abdominal area.

- If a woman becomes pregnant, she can ask her supervisor to reassign her to areas or assignments with less exposure to radiation.

When the mother's occupational exposures are kept below the regulatory limit of 5000 mrem per year, the risk to the unborn child is thought to be small. However, it is up to the mother to compare the benefits of continuing to work with radioactive material or a radiation producing device against the possible risks of occupational radiation exposure to her unborn child.

Any female radiation worker who knows, suspects, or is trying to become pregnant is strongly encouraged to contact the RSO as soon as possible to obtain information on pregnancy and prenatal radiation risks. All meetings and communications will be strictly confidential.

Internal Dose Calculations

Internal dose calculations will be performed, when necessary, using the bioassay results. Estimates of dose from internal exposure will be added to the individual's effective dose equivalent in accordance with applicable State and Federal regulations.

External Dosimetry and Bioassay Records

The RSO will maintain all records associated with the external dosimetry and bioassay monitoring program in accordance with applicable State and Federal regulations.

7. SAFE HANDLING PROCEDURES AND LABORATORY CONTROLS

Three fundamental objectives of radiation protection measures and safe handling protocols are:

1) To maintain worker exposures to external radiation ALARA and always keep worker exposures below established exposure limits.

2) To minimize the potential for the intake of radioactive material into a worker's body by ingestion, inhalation, absorption or injection when they handle unsealed radioactive material.

3) To maintain the integrity of experiments and experimental processes by preventing cross contamination of analytical samples.

General Safety Guidelines for Use and Handling of Radioactive Material

- ❖ New radiation workers must be provided practical instruction on nature of hazards they will be working with and ways to control prior to performing work. This instruction is the responsibility of the AU.

- ❖ Written standard operating procedures (SOPs) including hazards and controls should be available.

- ❖ Necessary equipment, shielding, waste containers, and survey instruments must be available.

- ❖ Procedures using radioactive material should be practiced using dry-runs using a non-radioactive, safe, substitute.

- ❖ A copy of the Radiation Safety Manual should be available to workers. *Note: The Radiation Safety Manual is available on the EHS&RM Safety web site.*

- ❖ Workers should be provided health and safety information about the specific radioisotopes they will be working with. The information should include the signs of exposure, potential health effects from exposure to the material and the regulatory annual limit of intake (ALI) for each isotope they will be using.

- ❖ Visitors and students in a laboratory where radioactive materials are present must be supervised by the AU or a qualified radiation worker at all times. Visitors and students are not allowed to use sources of radiation without prior approval and required training.

- ❖ Maintenance on potentially contaminated equipment (e.g. sink traps, floor tile, fume hoods and pumps in contaminated systems) or areas must be authorized by the AU and RSO before facilities maintenance personal begin work.

- ❖ All radioactive materials must be secured in a locked storage area when not attended by an authorized radiation worker.

- ❖ All work with radioactive materials should be performed in marked areas within a laboratory.

- ❖ When handling unsealed radioactive material, cover work surfaces such as countertops or the floor of a chemical hood with absorbent material to contain radioactive material contamination. Do not work with unsealed radioactive material on porous surfaces. The use of absorbent paper with a plastic backing recommended. If contaminated, discard the covering in a solid radioactive waste container, not regular trash.

- ❖ When handling radioactive liquids use absorbent-lined plastic or metal trays to contain small spills.

- ❖ Practice good housekeeping when working in radioactive material work areas. Keep the work area clean and well organized. Radioactive material work areas should only contain equipment required to perform the procedures.

- ❖ Keep liquid radioactive material in spill-proof secondary containment.

- ❖ Never pipette radioactive solutions by mouth. Always use some type of pipette filling device.

- ❖ Never eat, drink, apply cosmetics, or store food / drink in radioactive material labs or storage areas containing unsealed radioactive materials.

- ❖ Do not store food or drink in refrigerators / freezers in radioactive material laboratories.

- ❖ Do not smoke, use smokeless tobacco or chew gum in radioactive material labs containing unsealed radioactive sources.

- ❖ Always wash your hands and monitor yourself for contamination before leaving a lab after working with unsealed radioactive material.

- ❖ Always wear appropriate PPE whenever handling or working near unsealed radioactive materials. At a minimum this includes wearing safety eyewear, gloves, lab coat, long pants (or equivalent) and closed-toed shoes.

- ❖ Do not touch non-contaminated items such as phones, books, papers, door handles, drawer pulls, etc. while wearing potentially contaminated gloves worn when handling unsealed radioactive material.

- ❖ All reusable glassware and tools used with radioactive material should be thoroughly cleaned after use and checked for contamination after cleaning. Whenever possible, label glassware / equipment used for radioactive work and keep it separate from glassware / equipment used for non-radioactive work.

- ❖ Always wear any personnel radiation monitoring device that has been assigned to you whenever you are working in a radioactive material laboratory.

Always monitor yourself and your working area for radioactive contamination while working with and after working with unsealed radioactive material. If contamination is detected, follow the defined laboratory contamination protocols.

- ❖ Follow all laboratory protocols established for the disposal of radioactive waste and never put contaminated waste in regular trash.

Radioactive Material Laboratory Surfaces and Surface Coverings

The proper working surface and/or surface covering will enhance the ability to control and remove radioactive contamination in working areas. These include the use of non-porous materials on floors and work areas including:

- ❖ Stainless steel
- ❖ Plastic
- ❖ Linoleum
- ❖ Paint for porous cement floors

Lab benches should be lined with a protective covering to absorb spills and make decontamination easier. Absorbent poly-backed lab paper is recommended as a covering to control contamination when dry or small quantities of liquid materials are being handled. When handling larger quantities of radioactive liquid, a spill tray or small tub should be used to contain any liquid that may be spilled or splashed from the container. If unsealed material is being transferred from one work area or room to another the material should be placed in sturdy, spill proof secondary containment. Work surfaces should be surveyed while handling and after handling open radioactive sources using appropriate survey techniques.

Laboratory Engineering Controls

Chemical Fume / Exhaust Hoods

A common engineering control used to prevent inhalation of radioactive gases or vapors is a chemical fume hood. A fume hood is highly recommended when using volatile compounds (those which could reasonably become airborne). Examples of volatile radioactive compounds include I-125 or I-131 as NaI solution and tritiated water (HTO). In addition, nonvolatile compounds which are heated, agitated, powdered, or otherwise treated in the lab in a manner which could cause them to become airborne shall be performed in a fume hood.

The removal of radioactive material from fume hood exhaust is accomplished using a filter for particulates or by adsorption of iodine vapors in a charcoal filter. Radioactive material in particulate form can be removed using High Efficiency Particulate Air (HEPA) filters. HEPA filters are rated to remove a higher percentage of airborne particulate than normal filters.

Because iodine is released into the atmosphere as a vapor, HEPA filters are not effective at removing radioiodine from an exhaust airstream. Activated charcoal filters are used to remove radioiodine from the airstream by adsorption. Prefilters, or roughing filters, are often used to extend the life of the more costly final filter.

General Rules for Using Chemical Fume Hoods

Fume hoods used for volatile radioactive material work must be inspected and the air flow checked annually. The minimum air flow is 100 linear feet per minute with a sash height of 18 inches.

- ❖ More than 10 mCi of radioactive iodine (e.g., I-125 or I-131) cannot be used at any one time in any fume hood without having either charcoal filtration on the hood exhaust or RSC approval.
- ❖ Fume hoods should be lined with absorbent paper.
- ❖ Fume hoods should remain uncluttered and not used for as a storage area for radioactive material, chemicals or waste.
- ❖ Equipment and other materials should be placed a minimum of six inches behind the sash opening.
- ❖ The sash should be brought down as low as possible when working in the hood while still allowing adequate room to safely perform the procedure.
- ❖ The only time the fume hood should be fully open is during equipment setup.
- ❖ Large equipment should be blocked up at least 2 inches above the floor of the hood to allow unrestricted airflow beneath the equipment.
- ❖ Equipment and other materials should not be placed against the baffles at the back of the fume hood.
- ❖ Avoid rapid movements when working within the hood that might disrupt airflow.
- ❖ The sash should be kept closed when the hood is not in use.
- ❖ Do not allow paper and other light materials to be drawn into the duct work and the exhaust fan.
- ❖ At a minimum, safety eyewear, gloves, lab coat, long pants (or equivalent) and closed-toed shoes must be worn even when handling open radioactive material in a fume hood. The fume hood is an engineering control designed to protect workers from hazardous airborne particulate and fumes only.

General Safety Guidelines for X-Ray Devices and other Radiation Producing Machines

- ❖ Operators of any radiation producing machine or device must complete all required safety and operator training prior to using the equipment unsupervised.
- ❖ Written Standard Operating Procedures (SOPs) must be available to all operators.

X-ray equipment must not be operated in any manner other than that specified in the written procedures unless approved in writing by the RSO.

- ❖ Each area or room containing x-ray equipment shall be conspicuously posted with a sign bearing the radiation symbol and the words "CAUTION-- X-RAY EQUIPMENT".
- ❖ Bypassing equipment safety devices and interlocks is not allowed unless approved in writing by the RSO.
- ❖ When a safety device or interlock has been bypassed, a visible sign bearing the words "SAFETY DEVICE NOT WORKING" must be placed on the equipment housing.
- ❖ Finger or wrist dosimeters must be worn by workers:
    - o Using systems having an open-beam configuration that are not equipped with a safety device which prevents the entry of any portion of the worker's body into the primary x-ray beam or which causes the beam to be shut off upon entry into its path.
    - o By personnel maintaining x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.
- ❖ Radiation surveys must be performed by EHS&RM Radiation Safety staff or other personnel authorized in writing by the RSO:
    - o Upon installation of the equipment and at intervals not to exceed 12 months thereafter.
    - o Following any change in the initial arrangement, number, or type of local components in the system.
    - o Following any maintenance requiring the disassembly or removal of a local component in the system.
    - o During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed.
    - o Any time a visual inspection of the local components in the system reveals an abnormal condition.
    - o Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings exceed the radiation dose limits in Table 7.2.
- ❖ Radiation producing machines must not be left unattended in an operational mode unless the equipment / area are secure and the unattended operation is documented in an approved protocol.

- All equipment manufacturer requirements and recommendations for the safe operation of the equipment must be followed. Deviation from the manufacturer requirements or recommendations requires RSO approval.

- Proper maintenance of all radiation producing equipment is essential. All manufacturer instructions and recommendations for the maintenance of the equipment must be followed. Repairs to the equipment should be performed ONLY by properly trained technical personnel.

- Visitors and students must have the approval from and be supervised by the equipment operator to be in the area when the equipment is operating.

- A internal surveillance and radiation survey (analytical x-ray machines) will be performed at least annually by EHS&RM Radiation Safety staff.

Radioactive Animal Care Procedures, Laboratory Facilities and Equipment

Specific questions about the use of animals in experiments and animal care should be directed to the Chair of the Institutional Animal Care and Use Committee (IACUC). Guidelines for the care of animals and cages utilized in radioactive material experiments are found in Appendix D.

8. SECURITY AND STORAGE OF RADIOACTIVE MATERIAL & DEVICES

NMSU requires that all AUs and their workers maintain radioactive material in such a way that prevents theft, loss or misuse of such material, including radioactive waste. *All radioactive material stocks, waste, experiments, etc., no matter how small, should be secured in a locked location when unattended to prevent unauthorized access.* The AU is responsible for coordinating and maintaining security for their areas. Security includes physical barriers and procedural barriers. Unintentional loss or theft of radioactive material could result in unnecessary radiation exposure to the public and is a potentially serious violation of the NMED Radiation Protection regulations and the conditions on the NMSU Radioactive Material License. Security for all forms of radioactive material is essential. EHS&RM and inspectors from NMED will inspect for security of radioactive materials during laboratory surveys. Infractions are reported to AUs who are then responsible for developing and implementing corrective actions.

Radioactive Material Security Measures

Adequate security must be provided for:

- ❖ Unencapsulated or open radioactive material (stock and diluted material).
- ❖ Sealed sources including small calibration or check sources.
- ❖ Equipment containing radioactive sources such as electron capture detectors (ECD) and nuclear gauges (moisture/density gauges).
- ❖ Samples containing radioactive material.
- ❖ Radioactive waste.
- ❖ Operational keys for x-ray devices.

Physical barriers such as locked boxes or drawers, locked refrigerators, locked laboratory doors must be established to control access to radioactive materials. If a laboratory is unattended, radioactive materials and radioactive waste containers must be secured.

Procedural barriers limit access to only authorized individuals in restricted areas. These restricted areas and barriers are enforced by the AU and authorized workers. Any suspicious, unknown, or un-cleared persons in the area should be challenged and asked to leave the area. Only persons with proper training and a legitimate need should have keys to the laboratory.

The RSO must be immediately informed of any lost or stolen radioactive material or sources. Failure to do so will result in suspension or termination of the Radiation Use Permit. The RSO will assist in the effort to recover, investigate and report lost radioactive material.

Radioactive Material Storage Guidelines

Storage facilities for radioactive materials must be constructed or arranged to meet the criteria listed in this section.

If necessary, radiation levels near radioactive material and radioactive waste storage areas must be maintained ALARA by using appropriate shielding. If not shielded, storage areas must be positioned so the dose rates in common work areas are at acceptable levels.

Radioactive materials must be stored in locked containers when not attended. Containment can include such things as

- Locked cabinets or drawers.

- Locked radioactive material safes.

- Rooms or areas that are locked and secured at all times when authorized personnel are not present.

Unsealed liquid radioactive material must be stored in a closed container inside secondary containment.

Refrigerators or freezers where radioactive material is stored must locked whenever the lab is open and no authorized personnel are present in the lab. The units must also be posted with a radioactive material warning sign / label on the outside door.

The entrance to any area where radioactive materials or sources are stored must be posted with a "Caution, Radioactive Materials" sign. Additionally, the entry door must be posted with an "Emergency Procedures" sign (Form RS-5) or equivalent information.

Reporting the Loss of Radioactive Materials and Sources

A loss of radioactive material or radiation producing device must be immediately reported to the RSO. See Chapter 14 for more incidents which require that you to immediately notify the RSO.

9. REQUIRED POSTINGS AND CONTAINER LABELING

Area Postings

Radiation, X-Ray and Radioactive Material Signs

NMSU policy requires that the entry doors of all labs and storage areas containing any amount of radioactive material or a radiation producing device be posted with an appropriate warning sign. Additional signs may also be posted within labs on radioactive storage cabinets and work areas. Refrigerators / freezers used to store radioactive material must also be posted with a radioactive material warning sign / label on the outside door.

Radiation signs shall bear the radiation symbol of authorized color and background and wording consistent with regulations. In most cases, this is a yellow and magenta sign with the words "Caution, Radioactive Materials" for areas authorized for the use and storage of radioactive material or "Caution, X-ray Producing Equipment" in areas where these devices are authorized to be used.

Other signage may be required if the area dose rate meets the regulatory definition of a Radiation Area or High Radiation Area. These areas will be identified and posted as required during the RSC authorization process.

Specific work areas within a lab where radioactive materials are used should be delineated using "Radioactive Material" tape or by using a sign with the radiation symbol and words "Caution Radioactive Material" posted near the designated areas.

NMED Notice to Employees

Form NMED 045, "Notice to Employees", (Appendix A) must be posted in a sufficient number of places in areas authorized for the use and storage of radioactive material or where radiation producing devices are used to permit employees working in or frequenting any portion of a restricted area to observe it on the way to or from their place of employment. This form can be downloaded from the EHS&RM web site.

Emergency Procedures and Notification Sign (RS-5) or equivalent

Emergency spill procedures must be posted or readily available in each laboratory in which radioactive material activities are conducted. This sign or equivalent information shall also be posted on the entry door of labs or storage areas authorized for radioactive material use. This form can be downloaded from the EHS&RM web site.

Container Labeling

All containers of radioactive material must be properly labeled with identity of chemical contents, isotope and specific activity. The label must provide sufficient information to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposures. Prior to disposal of empty uncontaminated containers to an unrestricted area, the labels must be removed or defaced to indicate that the container no longer contains radioactive material. Use the RS-6 waste tag for waste containers.

10. RADIOACTIVE MATERIAL INVENTORY & SEALED SOURCE LEAK TEST

Semiannual Radioactive Materials Inventory

The radioactive material inventory at NMSU is required to be verified bi-annually as a condition of the NMSU radioactive material license. To meet this requirement the RSO distributes a Radioactive Materials Inventory Report (Form RS-4) to each AU twice a year. Each AU must verify and update all the information on the report then return a signed updated copy of the report to the RSO. The Radioactive Material Inventory report includes the following components:

- List of radioactive material in the AU inventory.
- List of authorized workers on the AU permit.
- Summary of authorized worker recent radiation safety training.
- List of authorized locations.
- List of survey meters assigned to the AU and last calibration date.
- Sewage disposal summary.

The reports are evaluated by the RSO and maintained as an inventory record for regulatory compliance.

Sealed Source Leak Testing

The leak testing of sealed radioactive sources must be conducted in accordance with the conditions listed in the NMSU Radioactive Materials License issued by the RCB (Appendix E). EH&S Radiation Safety staff typically perform leak testing services for AUs with sealed sources on main campus. Off-campus AUs with sealed sources are mailed leak test kits and trained personnel at the remote site perform leak test then mail back the test kit to EHS&RM for analysis. All leak test analyses are performed by a qualified vendor selected by the RSO.

<u>Sealed Source Leak Testing Guidelines</u>

- Sealed sources must not be opened or removed from their respective source holders by an AU or their staff.
- Except as specified below, sealed sources must be leak tested before being used and at six months intervals thereafter.
- Beta and gamma emitting sources containing less than 100 microcuries and alpha sources containing less than 10 microcuries of material are exempt from leak test requirements.

- ❖ Alpha-emitting sealed sources containing more than 10 microcuries of material must be tested at least at 3 month intervals unless specified by the source manufacturer.
  - This condition does not apply to Am-241: Be or Pu-239: Be sources which are neutron and gamma emitters, not alpha-emitters.

- ❖ Troxler Model 3411B portable nuclear gauges must be leak tested at least annually.

- ❖ Sealed sources that are stored and not being used are exempt from the leak testing requirement. However, they must be leak tested prior to being used or transferred to another person.
  - This exemption does not apply to alpha-emitting sealed sources which are still subject to leak testing requirements even when in storage.
  - A sealed source that is exempt from the leak test requirements is still subject to all radioactive material inventory requirements.

- ❖ Leak testing must be performed as directed by instrument manufacturer instructions. Typically, this includes wiping the outside of the source containment and surfaces of the device where contamination may accumulate.

- ❖ Leak testing must be performed by individuals who are trained and qualified to perform the testing.
  - EHS&RM Radiation Safety staff perform leak testing services for sealed sources on main campus.
  - EHS&RM provides the test kits to AUs with sealed sources at remote locations. Trained staff at the remote location perform the leak test and mail the test kit back to EHS&RM for analysis.

- ❖ Remote handling tools, such as tongs or long tipped swabs, should be used as appropriate, when performing the testing to reduce radiation dose to the worker's extremities.

- ❖ If the testing reveals the presence of 0.005 microcurie or more of removable contamination, the RSO will immediately contact the AU. The source must immediately be withdrawn from use until it is decontaminated, repaired or disposed of as radioactive waste.
  - The RSO will file a report with the RCB within five days of the positive test describing the equipment involved, the test results, and the corrective action taken.

11. RADIATION SURVEYS & SPILL DECONTAMINATION PROCEDURES

Radiation Dose Rate and Radioactive Contamination Surveys

Each AU is required to perform and document contamination surveys and area dose rate surveys of their approved radioactive material use areas. The purpose of the contamination surveys are to ensure that radioactive material remains controlled and within the radioisotope work or storage areas and radioactive contamination is detected in a timely manner. The purpose of area dose rate surveys is to verify that radiation exposure rates are kept ALARA for the protection of workers and the general public.

Radioactive Contamination Surveys

A potential source of radiation exposure to workers and the public from radioactive materials is from radioactive contamination. Radioactive contamination occurs when unencapsulated radioactive material is found in a location where is should not be. Routine contamination surveys are used to verify that radioactive material is contained. These surveys are an integral part of the NMSU Radiation Safety ALARA program.

Types of Radioactive Contamination

There are two types of radioactive contamination, removable contamination and fixed contamination. Total contamination is the combination of the fixed and removable contamination results. Contamination surveys are performed to detect and quantify radioactive contamination:

- *Removable contamination is contamination that is readily removable from a surface, normally by casual contact*. People or objects that come into contact with a surface with removable contamination may also become contaminated. Because removable contamination is transferable to a person's body it may pose an internal hazard if the contamination is ingested, inhaled or absorbed into the body. Removable contamination also may pose an external dose hazard as well.

- *Fixed contamination is contamination that cannot be readily removed from a surface*. The contamination is usually fixed in a surface by physical or chemical absorption into a surface or by entrapment in the cracks or pores of a surface. It is not an internal hazard for personnel but may pose an external radiation hazard if the radioactivity levels being emitted from fixed material are high enough.

- *Total contamination is the sum of the fixed contamination and removable contamination on a surface*. Most radioactive contamination found in NMSU labs is removable contamination. However, some labs may have a combination of both removable and fixed contamination.

Radioactive Contamination Limits

Removable radiation contamination limits are in Table 11.1. Some radioactive contamination is allowed in radiologically restricted areas. Restricted areas include secure radioisotope labs and storage rooms. These areas must be dedicated for use of radioactive materials, properly labeled, and mechanisms in place to prevent the spread of contamination.

In keeping with the NMSU ALARA program, the RSC recommends that if removable contamination is detected in restricted areas reasonable attempts should be made to reduce the contamination level to less than the Non-Radioactive Material Use limits found in Table 11.1. If removable contamination is detected in unrestricted areas, reasonable attempts should be made to reduce the contamination to below measurable levels.

Table 11.1 – Limits for Removable Surface Radioactive Contamination*

	Type of Radiation	
Surface Type	**Alpha (dpm/100 cm^2)**	**Beta / Gamma (dpm/100 cm^2)**
Non-Radioactive Material Use Areas	22	220
Radioactive Material Use Areas	220	2,200
Personal Clothing (in public areas)	22	220
Personal Clothing (in restricted areas)	220	2,200
Skin	220	220

*Values referenced from Table 2 of *NRC Regulatory Guide 8.23, Rev.1 – January, 1981*

Contamination Survey Frequency

EHS&RM strongly recommends that surveys be performed both during and after experiments using unsealed radioactive material. At a minimum, AU must perform surveys of all areas listed on their Use Permit at the frequency listed in Table 11.2. If an AU does not actively use radioactive material in a calendar month, they may document a "No Use" certification instead of filing their monthly survey report.

However, even if an AU is not actively using radioactive material but still has radioactive material in the laboratory (including in radioactive waste), a radiation safety survey must be completed. In this case, any location where radioactive material is located must be surveyed at least quarterly (once every 3 months). The monthly "No-Use" certification must still be documented in the AU's survey log for the other two months that a survey is not done.

EHS&RM Radiation Safety staff typically perform contamination surveys in active labs twice a year as a part of routine radiation safety surveillances. When these surveys are conducted by EHS&RM, the AU has the option of using these surveys as part of their required surveys if the report is kept in the AU's area survey log. A Radiation Survey Report template is available from EHS&RM to document required area surveys or an AU may use an equivalent alternate method.

Table 11.2 Contamination Survey Frequencies

Quantity of Unsealed Radioactive Material	Required Survey Frequency
< 200 microcurie per experiment	Monthly
> 200 microcurie per experiment	Weekly
> 1 millicurie (mCi) over course of one week	weekly
"Working with" 1 millicurie (mCi) at a time*	daily

* "Working with" includes withdrawing any amount of material from a stock solution containing an activity of 1 mCi or greater

<u>Performing a Removable Contamination Survey</u>

Contamination surveys should be performed in areas where contamination is likely and those areas where it is not expected such as in a hallway outside of a lab. Areas where contamination might be expected include fume hoods, sinks, storage and use areas, and the floor around these areas. Other areas that should be checked periodically include spots like door knobs, phones and computers. The information should be recorded (one form for each room) on a Contamination Monitoring Report or Survey Map.

- AU Name & Permit Number.
- Building & Room Number.
- Survey Date.
- Surveyor Signature or Initials.
- Analytical instrumentation (Liquid Scintillation Counter or other Analytical Instrument)
    - Make ○ Model ○ Serial Number
    - Calibration Date (if appropriate)
- Perform the survey:
    - Wear appropriate PPE (minimum PPE for handling open radioactive material is safety eyewear, gloves, lab coat, long pants and closed toed shoes) when Document the areas checked or where swipes are taken on a map of the area

- Using a piece of filter paper, laboratory tissue paper, or cotton swab, swipe an area of approximately 100 cm^2
  - Beware of cross-contamination of one swipe to another. If one wipe is highly contaminated, contamination from that swipe may be transferred to other swipes unless handled carefully.

- Count the swipes on an appropriate counter ○ Include one or two blanks (a piece of clean swipe material that has no radioactive contamination on it) to calculate the instrument background

- Record the blank (background) count rate (counts per minute or cpm)

- Record the swipe gross count rate (in cpm)

- Calculate the net count rate (cpm) by subtracting the background count rate (cpm) from the swipe gross count rate (cpm)

- Calculate the radioactivity on the swipe (in disintegrations per minute or dpm)

- Divide the net count rate by the instrument efficiency (cpm/dpm) for the isotope of interest.

- Compare the calculated activity against the contamination limits in Table 11.1.

- If removable contamination is detected, clean / decontaminate the area using techniques described in this chapter.
  - Re-swipe the area to verify decontamination was successful
  - If not, repeat cleaning / decontamination efforts until removable contamination values below allowable contamination limits for the type of area.

- Keep the survey documentation with the AUs radiation survey records.

<u>Performing / Documenting a Contamination Survey Using a Survey Meter</u>
The following steps should be performed to identify, quantify and document contamination survey results using a calibrated hand-held survey meter:

- Record (one form for each room) information on the Contamination Monitoring Report or other room diagram.

- Select the appropriate survey meter for the type and energy of radiation being detected.

- Perform a preoperational survey instrument inspection (similar to the inspection of an area radiation survey meter).

- Record the room identification, surveyor signature and date and survey instrument information (make, model, serial number, calibration date).

- Determine and record background reading by holding the meter over an area that is not contaminated.

- Turn on the audio, if available.

- Indicate areas surveyed by numbering locations on a map of the laboratory.

- Move the probe slowly over designated areas in a zigzag pattern (1 to 2 inches per second), listening for an increase in the pulse rate as an indication of increased activity.

- Hold the detector 1/2 inch or less from the surface (1/4 inch for suspected alpha contamination).

- If an area with an increased count rate is identified, determine and record the level of contamination (in disintegrations per minute) of the contaminated area and decontaminate.

- After decontaminating any area, resurvey to verify that the area is below allowable limits.

- Keep the survey documentation with the AUs radiation survey records.

Laboratory Counting Equipment

Laboratory counting equipment is stationary counting equipment that is used solely for analyzing radioactive samples, such as swipes taken during removable radioactive contamination surveys or sealed source leak tests. Laboratory counting equipment is typically much more sensitive with much lower MDAs. Some types of equipment can be used to identify unknown radioisotopes as well as quantifying the amount of activity in a sample.

Common types of laboratory counting equipment include liquid scintillation counters, gamma counters and alpha or gamma spectrometers. Liquid scintillation counters are very effective at detecting beta emitting nuclides including hydrogen-3, carbon-14, and sulfur-35. Gamma counters are used to detect photon radiation from a wide variety of radionuclides from iodine125 to cesium-137.

Choosing a System for Analyzing Removable Contamination Wipe Tests

The two types of instruments generally available for counting wipe tests for removable contamination are the gamma counter and the liquid scintillation counter. It is important that the instrument be appropriate for the type and energy of particle that is emitted by the radioactive material being measured. The counting efficiency should be known for the radioisotopes being used in the laboratory.

Table 11.3 Typical Efficiencies for Liquid Scintillation Counter

Nuclide	**% Efficiency**
H-3	60

C-14	90
P-32	95

Calibration of Laboratory Counting Instruments

Laboratory counting instruments used to analyze samples for removable contamination must be calibrated on an annual basis for the radioisotopes being used in the laboratory. Detection efficiency for radioisotopes used in the laboratory should be determined for the laboratory counting instrument.

Calculation of Minimum Detectable Activity (MDA) for Counting Instruments

Laboratory counters are typically more sensitive than portable contamination survey meters. The minimum detectable activity is a measure of the ability of the detection system to identify a measurable level of radioactive contamination above the background level of the counting instrument. The system used must have an MDA lower than the sensitivity required for the analysis (i.e. applicable regulatory limits).

$$MDA = \frac{(2.71/Ts) + 3.29\sqrt{(Rb/Tb)+(Rb/Ts)}}{(E)(A/100cm^2)}$$

where: Rb = Background count rate (cpm)

tb = Time of background count (minutes)

Ts = Time of the sample count (minutes)

E = Efficiency of the instrument for radioisotope being measured (cpm/dpm)

A = Area of the wiped surface (cm^2)

One way to improve (reduce) the MDA of a counting system is to increase the count time of the samples and blanks.

MDA Calculation Example 1: A liquid scintillation counter (LSC) is used to count contamination survey wipes for removable contamination of H-3 on a piece of laboratory equipment. With the following information, determine the minimum detectable activity.

$$MDA = \frac{(2.71/Ts) + 3.29\sqrt{(Rb/Tb)+(Rb/Ts)}}{(E)(A/100cm^2)}$$

$$= \frac{(2.71/Ts) + 3.29\sqrt{}}{(.35)(50/100cm^2)} \quad (49/5)+(49/1)$$

$$= 160\ dpm/100cm^2$$

Where:

R_B = Background (blank) count rate = 40 cpm

T_B = Background count time = 5 minutes

T_S = Sample count time = 1 minute

E = LSC efficiency for H-3 = 35% (0.35 cpm/dpm)
A = Area of wiped surface = 50 cm^2

MDA Example 2: A gamma counter is used to contamination survey wipes for I-125 removable contamination. The following information is available. Determine the minimum detectable activity for I-125.

$$MDA = \frac{2.71/Ts + 3.29\sqrt{R_B/T_B + R_B/T_S}}{(E)(A/100)}$$

$$= \frac{2.71/1min + 3.29\sqrt{102cpm/1min + 102cpm/1min}}{(0.45cpm/dpm)(100cm^2/100cm^2)}$$

MDA = 111 dpm/100cm^2
Where:
Background count rate = 102 cpm
Background count time = 1 minute
Sample count time = 1 minute
Gamma counter efficiency for I - 125 = 45 % (0.45 cpm/dpm)
Area of wiped surface = 100 cm^2

Area Dose Rate Surveys

Radiation protection regulations require that radiation levels in unrestricted areas be measured to demonstrate that no person in an unrestricted area shall receive a dose equivalent of **2 millirem in any one hour or 100 millirem in any one year**. These limits also apply to members of the public who enter restricted areas. This section covers the proper way to conduct and document an area does rate survey.

Choosing an Instrument for an Area Radiation Survey

Many factors are important in the selection of a portable contamination survey meter or counting system for detection and quantification of radioactive contamination. The goal is to select an instrument that will efficiently and effectively detect the radiation from the potential contamination. In general, the things to consider include:

- Type of radiation to be measured (alpha, beta, gamma) - Alpha particles and beta particles under 50 keV will not pass through the wall of a Geiger Mueller (GM) tube. A GM with a thin window is necessary to survey for alpha and beta particle emitting contamination. Most gammas can be measured with a GM tube or ion chamber.

- Energy of the radiation - The particle being surveyed must be energetic enough to enter the sensitive detector volume and create a signal for detection. Tritium (^3H) beta particles cannot enter an end-window GM detector. Swipe surveys using a laboratory counting instrument, such as a liquid scintillation counter, must be used to detect ^3H, contamination.

- The instrument chosen must be capable of detecting the radiation emitted by the radionuclide and must have the sensitivity to detect below levels listed in Table 11.1 or external dose rate limits defined in this section

Factors such as mixed radiation fields (beta/gamma or gamma/neutron), environmental conditions such as high humidity or temperature, and procedural requirements may also dictate the choice of an area radiation survey instrument. Before using a survey meter to perform an area radiation survey, ensure that you are specifically trained to use the instrument.

The most common type of portable radiation detection instrument is the Geiger- Mueller (GM) survey meter. It consists of a gas filled tube to detect the radiation and a meter to display the information. The GM detector is generally used to detect external photon (x-ray and gamma ray) radiation fields. It is not sensitive to neutrons. (A specialized detector is used for neutron detection.) A specific type of GM detector, called an end window GM, can also be used to detect alpha and beta particles. One end of this detector has a thin mica window that allows charged particles, such as alpha and beta particles, to enter the sensitive volume of the detector and be detected. This is useful for detecting radioactive contamination on surfaces.

A less common type of portable radiation detection instrument utilizes a thin window, thin crystal sodium iodide (NaI) detector which is particularly effective for identifying iodine-125 contamination.

Ion chambers are a type of portable radiation detection instrument typically used to monitor irradiators and x-ray machines.

<u>Area Dose or Exposure Measurement Units</u>
Area radiation surveys are typically expressed for photons as an exposure rate in milliroentgen per hour (mR/h) or millirem per hour (mrem/h) or as an integrated exposure in milliroentgen (mR) or millirem (mrem). Neutron surveys are expressed in mrem.

<u>Radiation Survey Instrument Calibration and Operational Checks</u>
Radiation survey instruments must be calibrated to ensure that the radiation level registered by the instrument is an accurate indication of the actual radiation field being measured when the instrument is used properly. This is accomplished by exposing the instrument to known radiation fields and adjusting the survey instrument so that the instrument displays the correct radiation levels.

Radiation survey instruments are **<u>required to be recalibrated when not responding properly to a check source, when serviced, or at an interval not to exceed one year</u>**. Calibrations must be performed by a qualified vendor or using procedures approved by the RSO.

An operation check should be performed before using an instrument.

- Perform a physical inspection of the instrument, checking for obvious physical damage.
- Verify that the instrument has been calibrated in the last twelve months. Perform a battery check to verify that the condition of the batteries is within acceptable limits.

- Perform a response check if a check source is available.
- Ensure that the audio is working if the meter has audio capability.
- If the instrument does not satisfactorily complete the preoperational inspection, tag it "out of service" and have the instrument repaired and/or calibrated.

Performing & Documenting Area Radiation Surveys

The following information should be recorded on the area radiation survey record:

- Date performed.
- Survey location.
- Survey instrument information (make, model, serial number).
- Name of person performing survey.
- Description of conditions under which the survey is performed which may affect the radiation level being measured.
- Radiation levels are normally taken at a height of one meter and at varying distances from the source.
- Radiation fields through a surface (e.g. beyond a wall or a shield) are taken at a distance of one foot beyond that surface.
- Units of mR/h, mSv/h, or mrem/h can be used for photon radiation dose measurements.
- Keep the area survey documentation in the AUs laboratory survey records.

Small Spill Response and Area Decontamination

Large spills (greater than 100 μCi, of any isotope), personnel contamination, or injuries involving radioactive materials are considered an emergency and must be reported to the RSO immediately. See Chapter 14 Emergency Procedures.

This section discusses guidelines to follow in the event that a non-emergency spill occurs or removable contamination is found during a routine laboratory survey. Decontamination of laboratories will be much more efficient and prompt if appropriate planning and precautions are made ahead of time. These general guidelines that should be followed whenever a small spill occurs or removable contamination is found during a radiation survey.

General Radioactive Spill Response / Area Decontamination Procedures

- Notify all persons in the area that a spill has occurred or radioactive contamination has been detected.

Prevent the spread of contamination by covering the spill with absorbent paper

- Restricting access to the area to those workers directly involved in cleanup activities.
- Don appropriate PPE. At a minimum this is safety eyewear, gloves, lab coat, long pants, and closed toed shoes. If the floor is contaminated shoe covers should be worn.
- Use an appropriate survey meter for the isotope to help assess the extent of the contamination and verify decontamination efforts. Low energy isotopes (^{3}H, ^{14}C, ^{35}S) will require swipes and liquid scintillation counting to assess the spill.
- Begin clean up by starting to wipe up the contamination at the edges of the contaminated area and working inward.
- If a large amount of a gamma or high energy beta-emitter has been spilled, manipulate the cleaning rags or towels with long forceps or tongs; this will significantly reduce hand exposure.
- After removing as much of the spilled material as possible by wiping it, up use a soap and water or other commercial decontamination product to remove the remainder of the contamination.
- All cleanup materials (i.e. paper towels, absorbent paper, gloves) should be placed into a plastic bag or bucket for disposal as radioactive waste. Attach a completed RS-6 waste tag on the container and call EHS&RM for a pick up or place it into the appropriate laboratory radioactive waste container.
- Resurvey the area to verify cleanup efforts were successful.
- Document the spill on a contamination monitoring report and keep with the AU survey records.
- Contact EHS&RM Radiation Safety if advice or assistance is required.

Radioactive Spill Response Kit

One of the best preparations for a spill or contamination incident is to have a spill kit. A spill kit is a portable container that is centrally located and can be transported to the scene of a spill. It is important to locate the spill kit in an area where it can be accessed even during an emergency.

Spill kits need to be inventoried from time to time to ensure that they contain all necessary items and that the material is not outdated or non-functional. Spill kits should not be used as a source of regular laboratory supplies. The use of the spill kit should be incorporated into regular drills or exercises.

A commercial spill kit is normally in one or more suitcase-size containers. Other possibilities include using a large plastic bucket with securable lid, nylon blanket with sized pockets sewn over the area. The blanket may be rolled up and stored or even placed on a wall, available for use in an emergency. Plastic tamper seals can be placed on the spill kit with the date of the last inventory. The following identifies minimum inventory which should be included in the spill kit. Additional items should be added as deemed necessary for individual laboratories.

It is the responsibility of each AU to maintain essential decontamination supplies in his/her laboratory. Environmental Health & Safety will provide a basic spill kit which must be maintained by the AU. This kit consists of a 5 gallon bucket stocked with the following supplies:

- **vermiculite**
- **gloves** (disposable latex or neoprene)
- **shoe covers** (disposable tyvek)
- **heavy duty plastic bags** for collecting used absorbent materials and contaminated articles

- **small sponge** (suitable for skin decontamination)
- **signs** ("Caution: Contaminated Area")

- The following supplies should be readily available in the work area or added to the basic spill kit.

- **absorbent towels** (disposable)
- **mild soap** (e.g. Joy or hand soap, suitable for skin decontamination)
- **small soft brush** (suitable for skin decontamination, e.g. complexion brush)
- **nail clippers** (for removing contaminated fingernails)
- **decontaminating solutions** (e.g. Radiac-Wash, Rad-Con, Count Off, etc.)
- **scouring pad**
- **disposable mop**
- **broom and dust pan**
- **tape** ("Caution: Radioactive Materials" or "Caution: Contaminated Area")

12. PROCUREMENT, RECEIPT AND SHIPPING

Any individual seeking to obtain radioactive material, sealed sources or radiation generating devices must first be authorized by the RSC. Only an AU or an authorized radiation worker and may procure and receive permitted radioactive materials or devices.

Procurement of Radioactive Material or Radiation Emitting Devices

The RSO must approve all orders for radioactive material to ensure that the requested material, quantities, manufacturer, and model are authorized by the license and license possession limits are not exceeded. An order authorization number will be provided to the AU if the material requested (isotope, activity and chemical form) is on the user's RSC authorization (permit).

Contact Radiation Safety at 646-3327 to obtain the '***authorization number***' prior to procuring or transferring any radioactive materials. Purchase orders, requisitions and procurement cards may be used to procure materials or devices provided that the authorization number has first been obtained.

All radioactive material packages must be delivered to EHS&RM receiving facility during normal business hours (8 AM - 5 PM, Monday through Friday). Radioactive material orders cannot be accepted outside of normal working hours unless prior arrangements have been made with the RSO. The shipping address for all radioactive material orders is:

Environmental Health Safety & Risk Management
New Mexico State University
1635 Standley Drive
Las Cruces, NM 88003-8001
Attn: *AU Name*

Radioactive Material Receipt and Check In

All package surveys, contamination monitoring and other required check-in procedures and documentation as required by state and federal regulations will be performed and documented by EHS&RM Radiation Safety staff.

EHS&RM Radiation Safety staff will notify the requestor of shipment arrival and ask for a designated individual to be present for delivery of the radioactive material to the laboratory.

The package will be opened by EHS&RM Radiation Safety staff and inspected if external swipes indicate removable contamination levels above DOT limits, or if dose rates are above DOT limits, or if there is obvious package damage that might have compromised the contents.

EHS&RM Radiation Safety staff will attempt to deliver shipment (after phone contact) to the AU or previously identified alternate within four hours of receipt. Two exceptions may prevent this delivery time.

- First, if the shipment arrives after 2:00 PM, the shipment may be delivered the next working day.
- Second, if the designated individual is not available to accept the delivery. Shipments being held by EHS&RM will be stored according to markings on the exterior of the container.

- A Radioactive Material Package Wipe Test Report and Usage Logsheet (Form RS-7) will accompany each package of radioactive material delivered. This report documents the results of the shipment contamination monitoring and survey. The Usage Log Sheet must maintained by the AU until final disposition of the material. When the material has been used or disposed, a copy of the completed form must be returned to the RSO. After the package is delivered to the lab the AU or trained staff must:

- Open the package and verify that the contents agree with the packing slip information.

- Check the integrity of the internal container (i.e., inspect for breakage of seats or vials, loss of liquid or discoloration of packaging material).

- Maintain the source Radioactive Material Package Wipe Test Report and Usage Logsheet in the laboratory radioactive material inventory records.

- Monitor empty packaging material for contamination and if not contaminated discard the packaging in regular trash after obliterating all radioactive and other hazard labels. If packaging is contaminated, treat the packaging as radioactive waste.

If there is a problem with the shipment immediately notify the RSO to discuss options.

Internal Transfers of Radioactive Material & Radiation Emitting Devices

All internal transfers (AU to AU) of licensed material require written prior approval from the RSO (646-3327). Transfers of material must be done in a way that minimizes the probability of spillage or breakage. Primary containers should be placed into secondary containment before transported. Appropriate container shielding should be used if the dose rate on the outer surface of the container is high.

External Transfers of Radioactive Material & Radiation Emitting Devices

Licensed materials must not be transferred or shipped to an outside entity (person or institution) without written prior approval of the RSO. All transfer / shipments of licensed material be processed through the RSO to ensure materials are properly packaged and labeled in accordance with applicable DOT, NRC and other regulations.

Radioactive Gifts or Donations

Any gifts or donations made to the university by individuals or institutions which contain radioactive material or are a radiation producing device requires written prior approval of the RSO before transferred to NMSU. The RSO will ensure the transfer is done in accordance with applicable regulations and the conditions of the university license.

Shipping Radioactive Materials & Sealed Radioactive Sources

Notify the RSO (646-3327) to arrange for shipping of all radioactive materials, and radiation producing devices. Advanced notice is required to ensure the "ship to" receiver is licensed to receive the material and to give EHS&RM time to perform required contamination surveys and / or leak tests and prepare the package for shipment.

Examples of commercial shipments that must be coordinated through EHS&RM Radiation Safety:

- ❖ Sealed sources such as nuclear gauges or electron capture detectors (ECDs) to be shipped to a manufacturer for calibration or repair.

- ❖ Shipment of radioactive material or radioactive samples to a researcher at another university.

- ❖ Transfer of an x-ray machine to another institution.

Transportation of Portable Nuclear Gauges to Authorized Field Sites

Soil moisture/density gauges containing radioactive sources (portable nuclear gauges) may be transported for use in the field by trained NMSU employees in a government vehicle. Regardless of destination, nuclear gauges must be transported according to strict guidelines established by the Department of Transportation. DOT Hazardous Material Transportation training is required for each individual that transports a gauge and refresher training must be completed every three years.

The AU must ensure all workers using or transporting a portable nuclear have been fully trained and are qualified to perform the job. The AU must ensure that all required transportation documentation is maintained and all shipping requirements are followed by workers that transport portable nuclear gauges. Detailed procedures for the use and transportation of portable nuclear gauges are available under the Radiation Safety Program section of the EHS&RM web site.
A summary of the protocol is included in Appendix H.

13. RADIOACTIVE WASTE MANAGEMENT

The NMSU waste program is designed to minimize waste disposal costs and radiation exposure to individuals and the environment. The waste program will not be successful unless a firm commitment is made by those who use radioactive materials to follow proper protocols when generating and handling radioactive waste. The generation of mixed waste, consisting of hazardous chemical and radiological components, should be avoided whenever possible as it requires very expensive pretreatment before it can be disposed.

The generation of radioactive waste should be minimized using techniques such as screening waste before putting it into a radioactive waste container or using non-radioactive substitutes when possible. Radioactive waste must meet handled and disposed following the criteria outlined in this chapter.

Special Radioactive Wastes (Mixed, Biological, Pathogenic or Infectious Waste)

These wastes consist of hazardous, biological, pathogenic or infectious material that is contaminated with radioactivity. This type of waste must be treated to reduce, to the maximum extent practicable, the potential hazard from the non-radiological materials prior to disposal. Some wastes will have multiple characteristics and more difficult and expensive to dispose. If the AU expects to generate a mixed or special waste they should contact the RSO for guidance.

General Guidelines for Handling & Disposal of Radioactive Waste

- Designate an area within your laboratory for storage of radioactive waste.

- Do not store waste containers in chemical fume hoods.

- Control and secure your radioactive waste in accordance with the Control and Security of Radioactive Materials.

- Activity in your radioactive waste must be counted as a part of your radioactive material inventory until it is physically removed by EHS&RM personnel.

- Label all radioactive waste containers with a "Radioactive Materials" label.

- Primary liquid waste containers must be kept in secondary containment large enough to store the entire volume of liquid in the primary container.

- Do not over fill liquid waste containers. Fill the container until it is approximately 90% full leaving enough headspace to allow for liquid expansion. Containers over 90% full will not be picked up by EHS&RM. Complete a RS-6 Waste Tag; include a complete description of the chemical composition of the liquid, isotope and total isotope activity on the tag.

- Shield the waste container using appropriate shielding if the dose rate near the container is greater than or equal to 2 millirem / hour (0.02 millisieverts / hour).

- ❖ Keep radioactive waste containers closed when not in use.

- ❖ Do not dispose of liquids down your sink unless drain disposal is specifically authorized as a condition on your Use Permit. Authorized drain disposal must be performed using specific, approved procedures.

- ❖ Do not dispose of radioactive waste in regular trash.

- ❖ Do not mix radioactive material with other hazardous material unless it is absolutely required by your use. The waste generated from the process will likely be “mixed waste” (has both radioactive and hazardous waste characteristics). There are only a few disposal options for mixed wastes and disposal costs can be extremely high. If you must generate mixed waste, contact the RSO to review ways to minimize the volume of the mixed waste.

- ❖ All waste containers must have a completed Radioactive Waste Tag attached before calling EHS&RM for a pick-up (646-3327)

Dry Solid Radioactive Wastes

This type of waste includes laboratory trash, absorbent paper, plastic containers, disposable gloves, test tubes, paper towels, etc.

- ❖ Do not place free liquids or containers with greater than microliter (μL) quantities of liquid in dry solid waste containers.

- ❖ Do not put lead shielding, lead containers (including plastic-covered lead “pigs”) or any other type of hazardous material in dry solid waste containers. This type of waste must be segregated from other dry solid waste until picked up by EHS&RM.

- ❖ Segregate waste streams by isotope unless otherwise authorized by a condition on your Use Permit. Exception: C-14 and H-3 waste may be mixed but C-14 and H-3 activity must be tracked separately and listed separately on the RS-6 waste tag.

- ❖ Collect dry solid waste in a fiber drum or other sturdy container lined with 2 thick poly bags. Label the outside of the container with a "Radioactive Materials" label.

- ❖ Complete a RS-6 Radiological Waste Tag, attach it to the container and call EHS&RM for a pick-up (646-3327).

Radioactive Sharps

- ❖ Puncture hazards (broken glass, glass pipettes, needles, etc.) must be collected separately a rigid, puncture proof container labeled with “SHARPS” and a "Radioactive Materials" label.

- ❖ Close the container securely when full and then sealed inside a thick poly bag.

- ❖ Complete a RS-6 Radiological Waste Tag, attach it to the container and call EHS&RM for a pick-up (646-3327)

Liquid Scintillation Cocktail Vials

Note: The use of biodegradable, “environmentally safe” scintillation cocktails are strongly encouraged. Xylene, toluene or methanol based cocktails combined with radioactive material are considered “mixed waste”. The disposal options for mixed waste are very limited and disposal costs are extremely high.

- ❖ Put full vials either back into the vial flats or into a leak-proof plastic bucket lined with a thick poly bag. Label the outside container with a "Radioactive Materials" label.
- ❖ Keep the waste container closed when not in use.
- ❖ Do not dispose of cocktail down a sink.
- ❖ Do not mix different types of liquid scintillation cocktail in same waste container without prior approval from the RSO.
- ❖ Segregate the vials by isotope. Exception: C-14 and H-3 can be mixed but C-14 and H-3 activities tracked separately and listed separately on the waste ticket.
- ❖ Segregate C-14 and H-3 cocktail having an activity concentration of less than 0.05 microcurie / milliliter (μCi/mL).
- ❖ When the container is full, seal the inner poly liner and plastic outer container. If in flats, make sure all vial caps are tight and sealed the flat inside a poly bag.
- ❖ Complete a RS-6 Waste Tag; include the brand name of the cocktail in the vials in the description.
- ❖ Attach the waste tag to the container and call EHS&RM for pick-up (646-3327)

Bulk Liquid Scintillation Fluids

Note: The use of biodegradable, “environmentally safe” scintillation cocktails are strongly encouraged. Xylene, toluene or methanol based cocktails combined with radioactive material are considered “mixed waste”. The disposal options for mixed waste are very limited and disposal costs are extremely high.

- ❖ Store bulk cocktail in containers supplied by EHS&RM. Label the container with a "Radioactive Materials" label.

- ❖ Primary liquid waste containers must be kept in secondary containment large enough to store the entire volume of liquid in the primary container. The AU must provide the secondary containment.

- ❖ Keep the waste container closed when not in use.

- ❖ Segregate the cocktail by isotope. Exception: C-14 and H-3 can be mixed but C-14 and H-3 activities tracked separately and listed separately on the waste ticket.

- ❖ Segregate C-14 and H-3 cocktail having an activity concentration of less than 0.05 microcurie / milliliter (µCi/mL).

- ❖ Do not dispose of cocktail down a sink.

- ❖ Do not mix different types of liquid scintillation cocktail in same waste container without prior approval of the RSO.

- ❖ Do not over fill liquid waste containers. Fill the container until it is approximately 90% full leaving enough headspace to allow for liquid expansion. Waste containers that are over 90% full will not be picked up by EHS&RM.

- ❖ When full, seal the container.

- ❖ Complete a RS-6 Waste Tag; include the brand name of the cocktail in the vials in the description.

- ❖ Attach the waste tag to the container and call EHS&RM for pick-up (646-3327)

Liquid Radioactive Wastes

Liquid radioactive wastes may be either aqueous waste or mixed waste. Aqueous waste is water soluble waste that does not contain any hazardous material other than the radioactive compound. Mixed waste is a liquid that contains both radioactive and hazardous material (has both radioactive and hazardous waste characteristics). The disposal options for mixed waste are very limited and disposal costs can be extremely high. If you must generate mixed waste, contact the RSO to review ways to minimize the volume of the mixed waste.

- ❖ Store liquid waste in containers supplied by EHS&RM.

- ❖ Liquid waste containers must be kept in secondary containment large enough to store the entire volume of liquid in the primary container. The AU must provide the secondary containment.

- ❖ Label the container with a "Radioactive Materials" label, the chemical name or composition of the liquid and a chemical hazard label.

- ❖ Keep the waste container closed when not in use.

- ❖ Keep the pH of liquid greater than 5 and less than 12.5.

- ❖ Do not dispose of liquids down your sink unless drain disposal is specifically authorized as a condition on your Use Permit. Authorized drain disposal must be performed using specific, approved procedures.

- ❖ Do not over fill the liquid waste container. Fill the container until it is approximately 90% full leaving enough headspace to allow for liquid expansion. Waste containers that are over 90% full will not be picked up by EHS&RM.

- ❖ When full, seal the waste container.

- ❖ Complete a RS-6 Waste Tag; include a complete description of the chemical composition of the liquid, isotope and total isotope activity on the tag.

- ❖ Attach the tag to the container and call EHS&RM for a pick-up (646-3327).

Original Stock Vials

- ❖ If a stock vial is NOT EMPTY, place it in a "pig" for shielding and segregate it from other wastes until picked-up for disposal by EHS&RM.

- ❖ Complete a RS-6 Waste Tag, attach the tag to the container. Call EHS&RM for a pick-up (6463327)

- ❖ If the stock vial is empty, it can be placed in the dry, solid radioactive waste.

- ❖ Empty plastic screw-top containers can be placed in the dry, solid radioactive waste as long as the top is unscrewed from the bottom.

- ❖ Do not put plastic-covered lead "pigs" or other lead shielding in dry solid waste. This type of waste must be segregated from other dry solid waste until picked up by EHS&RM.

Uranium or Thorium Containing Chemicals

- ❖ Uranium and thorium containing chemicals (i.e. uranyl nitrate, uranyl acetate, thorium nitrate) and associate wastes must be disposed as a radioactive waste.

- ❖ If the material is in the original bottle, complete a RS-6 Waste Tag, attach the tag to the bottle and call EHS&RM for a pick-up (646-3327).

- ❖ For dry or liquid wastes created from using these compounds, follow the appropriate guidance for the waste form described in this section.

Radioactive Biological Wastes

Biological wastes consist of animal carcasses, biological tissues, blood, and other human or animal secretions that have been contaminated with radioactivity.

- ❖ Place carcasses and tissues in thick opaque plastic bags and place in a freezer approved for the storage of radioactive materials until arrangements can be made for pick-up by EHS&RM.

- ❖ Biological fluids in sealed containers should be kept frozen until arrangement can be made for disposal.

- ❖ Segregate biological waste containing C-14 and H-3 with concentrations less than 0.05 microcurie / gram (μCi/g) from other biological waste.

- ❖ Complete a RS-6 Waste Tag and contact EHS&RM to arrange disposal of radioactive biological wastes (646-3327).

Disposal by Decay-in-Storage

Decay-in-Storage wastes include any solid or liquid waste contaminated with radioisotopes having a physical half-life of 120 days or less. These types of wastes can be decayed in the laboratory or transferred to EHS&RM for decay prior to being disposed as non-radioactive waste.

<u>Using EH&S for Disposal</u>

- ❖ Place the waste in the container provided by EHS&RM.

- ❖ Segregate wastes by isotope and chemical composition

- ❖ Label the container with a "Radioactive Materials" label, the chemical name or composition of the liquid and a chemical hazard label as appropriate.

- ❖ Log the date and quantity of material each time waste is added to the container

- ❖ Seal the container when it is full and log the date the container is closed, isotope and total activity in the container.

- ❖ Complete a RS-6 Waste Tag for each container

- ❖ Call EHS&RM for pick-up (646-3327)

<u>Procedure for Disposal by the AU</u>

- ❖ Place the waste in the container provided by EHS&RM.

- ❖ Segregate wastes by isotope and chemical composition

- ❖ Label the container with a "Radioactive Materials" label, the chemical name or composition of the liquid and a chemical hazard label as appropriate.

- ❖ Log the date and quantity of material each time waste is added to the container
- ❖ Seal the container when it is full and log the date the container is closed, isotope and total activity in the container.
- ❖ After 10 physical half-lives of isotope have elapsed, survey waste in a low-background area using a calibrated survey meter.
- ❖ If radiation levels are indistinguishable from background, the waste can be disposed of as non-radioactive waste; if not, reseal the container and continue to store until levels are indistinguishable from background.
- ❖ Remove or deface all radiation and other hazard labels.
- ❖ Dispose of the waste as appropriate for the non-radioactive form of the waste.
- ❖ A record of the final waste survey and final disposition of the waste must be maintained by the AU (logbook recommended). The record must list the radioisotope, original activity, date placed into decay-in-storage, date of final survey, individual performing the final survey, the manufacturer, model, serial number, the calibration date of the survey meter used and the final disposition of the waste.
- ❖ Radiation level surveys and surveys for removable contamination should be performed at least monthly in the designated decay-in-storage areas. Records of all surveys date of disposal and final disposition must be maintained by the AU.

Disposal to Sanitary Sewer System

- ❖ Disposal of any radioactive material to the sanitary sewer system must be authorized by the RSC or RSO. AUs must request in writing that they want to use this method of disposal. If granted, an allowance for sewage disposal of certain aqueous wastes will be noted on the permit (see Appendix A, Form RS-2). Aqueous radioactive wastes that are readily soluble in water may be disposed of via the sanitary sewerage system provided the AU is permitted to do so and the concentration and the following criteria are observed.
- ❖ The AU must monitor and document all disposal activity to ensure all criteria are met.
- ❖ One sink in the lab must be designated for all disposal activities and labeled with a "Caution Radioactive Material" sign.
- ❖ Lab personnel should not use the sink for any other activity until the sink has been surveyed and cleared of potential contamination.
- ❖ The AU must ensure that the sanitary sewer system monthly maximum and concentration limits for materials disposed do not exceed the limits specified in Table 13.1 below. For isotopes not listed, the RSO will provide the allowable release limit.

- All material disposed must be readily soluble or readily dispersible biological material in water and not otherwise regulated as hazardous or toxic.

- The AU must ensure that an accurate record is kept each time waste is disposed down the sink (logbook is recommended).

- Accurate records of sewerage disposal must be maintained and submitted to the RSO along with the semiannual Radioactive Materials Inventory (Form RS-5).

Table 13.1 Sewer Disposal Limits for Selected Radioisotopes

Isotope	Maximum Monthly Sewer Disposal per AU[1] µCi	NMSU Monthly Average Concentration Allowable in Sewer Water[2] (µCi/mL)
^{3}H	800	$1x10^{-2}$
^{14}C	170	$3x10^{-4}$
^{32}P	170	$9x10^{-5}$
^{35}S	170	$1x10^{-3}$
^{45}Ca	170	$2x10^{-4}$
^{125}I	170	$2x10^{-5}$
All Uranium	170	$3x10^{-6}$

[1] Maximum allowable monthly quantity of drain disposed isotope per authorized Permit (based on 50 AUs x 10%) [2] Maximum allowable monthly concentrations if diluted by the lowest average monthly quantity of sewage (8.1 x 10^6 gallons) released into the sewer by the licensee, specified in 20 NMAC 3.1, Subpart 4, Appendix B, Table III.

Radioactive Material Disposal Records

Prior to disposal of radioactive material a Form RS-6 (Radiological Waste Tag) must completed by the generator and attached to each waste container prior to pick-up by EHS&RM. In addition to completing waste description, the waste generator must obtain the tracking/inventory number from Form RS-7 (see below) and write this number onto the RS-6 tag. Note: the authorization number for procurement and the tracking number are not the same.

As radioactive material is used, transferred, or disposed, the AU must track final disposition for inventory control. This includes documenting any disposal by decay, transfer to licensed user, release to EHS&RM, or sanitary sewer (if allowable). Form RS-7, Radioactive Material Package Wipe Test and Usage Log sheet or equivalent should be utilized for record keeping. Forward completed Usage Log sheet to EHS&RM when material is completely used or disposed and your inventory will be updated by EHS&RM.

14. EMERGENCY PROCEDURES

Table 14.1 Emergency Telephone Numbers	
Contact	**Phone Numbers**
David Schoep Radiation Safety Officer	575-646-3327 (Office) / 575-312-6649 (Cell)
Dr. Katrina Doolittle Executive Director for EHS&RM	575-646-3327 (Office) / 575-644-2676 (Cell)
NMSU Police / Fire	911 (Emergency) / 575-646-3311(Non-Emergency)
New Mexico Department of Public Safety	505-827-9329 (24 Hour Emergency)

Emergencies and Incidents Involving Radioactive Material

Notify the RSO at the numbers listed in this section as soon as possible of any abnormal or questionable situation involving ionizing radiation or radiation-producing devices including:

- Loss or theft of radioactive material or a radiation producing device
- Large radioactive material spills.
- Extensive contamination of personnel or a facility.
- Suspected worker exposure above an administrative control limit.
- Radioactive material intake by a worker.
- Unauthorized release of radioactive material to the air or sanitary sewer.
- Other abnormal event involving radioactive material or a radiation producing device.

The RSO will provide advice, support and guidance as appropriate. The RSO with the help of the AU will also make any necessary notifications to the RCB as described in Chapter 15.

Procedure for Treating Injured Workers Involving Radioactive Contamination

Personnel who use radioactive material are highly trained and are aware of the hazards associated with radiation. ***No procedures involving radioactive material, including decontamination, should interfere with life saving measures or critical medical treatment.*** Only after the victim has received medical attention should radioactive contamination control be the priority. In most cases medical and radiation concerns can be addressed concurrently. In the worst case, decontamination can be delayed until after medical treatment. This may be more complicated but is an acceptable trade-off for providing prompt medical attention to injured personnel.

- Lifesaving or critical medical treatment actions should be taken immediately.

- Wear disposable gloves while treating the patient. Assess the medical condition of the victim and obtain medical treatment as necessary.

- Provide information concerning the spill or exposure to radioactive material to the medical team attending the victim**.**

- If radioactive contamination is involved, also notify the medical facility that will be receiving the patient and provide appropriate radiation safety guidance.

Major Radioactive Material Spill Procedures

The procedures for handling a large, uncontained spill (greater than 100 μCi) of any radionuclide or grossly contaminated personnel include:

- Immediately notify all persons in the area that a had a spill of radioactive material has occurred.

- Evacuate all personnel not directly involved in the spill. Survey all individuals for contamination as they exit the room or have them remain in a designated area until they can be checked. Survey the soles of shoes, hands and outer clothing worn by these individuals to minimize the spread of contamination outside the area.

- Stop the spill and take steps to minimize the spread of contamination if possible to do so without contaminating yourself.
    - Cover the spill with an absorber or damp pad (if dry material).
    - Close all doors and windows and shut down room ventilation to prevent dispersion of dusts, fumes, or gases.
    - Limit movements of personnel who may be contaminated and have them stay in a safe designated area near the spill until they can be surveyed for contamination.

- Shield the spill if necessary. Do only if it can be done without spreading contamination or exposing personnel to a significant dose of radiation.

- Prevent unauthorized entry to the area by closing the door to the room and placing a "Caution: Contaminated Area" sign or warning tape across the entrance. If possible, station someone near the entrance.

- Immediately report the incident to the RSO at the emergency numbers listed in this section.

- Begin decontamination of personnel immediately if necessary, following procedures the personnel decontamination procedures described in this section.

- Clean up the spill after donning the appropriate PPE, survey instrumentation and clean up materials. Follow the radioactive spill clean-up procedures outlined in Chapter 11.

Personnel Decontamination Procedures

Many times a person who appears to be contaminated may simply have contamination on their clothing which can be removed and isolated until decontaminated or disposed. Begin decontamination efforts as soon as contamination is suspected. Segregate waste generated during the decontamination process for disposal as radioactive waste.

- ❖ Notify the RSO immediately at the emergency numbers in this section if decontamination efforts go beyond the washing of hands or removal of contaminated clothing.

- ❖ Remove contaminated clothing and place in a plastic bag.

- ❖ Flush contaminated skin with lukewarm water.

- ❖ Wash contaminated skin with a mild soap.
  - o Use of a small sponge or soft brush (e.g., complexion brush) may be helpful.
  - o Avoid irritating the skin.

- ❖ Monitor the area for contamination after each series of washing and rinsing to determine the effectiveness of the decontamination efforts and repeat washing if necessary.

- ❖ If fingernails or fingertips are contaminated, **clip nails** as short as possible.

- ❖ If contamination persists, **induce perspiration** by covering the area with plastic (e.g. place a latex or vinyl glove over a contaminated hand, and tape opening at wrist). Then wash the affected area again to remove any contamination that was released by the perspiration.

- ❖ Terminate decontamination efforts when:
  - o All radioactive contamination has been removed; or
  - o surveys following each of several successive decontamination steps indicate that contamination levels are no longer decreasing; or
  - o Erythema (reddening of the skin) has occurred.

- ❖ Document the incident and submit copy of the incident report to the RSO.

Theft, Loss or Environmental Release of Radioactive Material

In the event that radioactive material is lost, stolen or accidently released to the environment **immediately notify the RSO at the emergency numbers listed in this section**. The RSO will provide specific guidance and assistance.

15. FORMAL NOTIFICATION OF INCIDENTS & EMERGENCIES

This section describes the time-frames and methods the RSO must comply with to formally report various types of incidents and emergencies involving radioactive material or exposures to radiation to the RCB. The AU and staff must inform and assist the RSO, as necessary, with complying with these regulatory reporting requirements.

Immediate Telephone Reports to RCB

The State requires immediate reporting of the following incidents. Therefore, each Authorized User and any other individual involved must immediately notify the RSO by telephone of an incident and the RSO will communicate with the appropriate State Agency. The following incidents must be reported:

- Theft or loss of radioactive material.
- Exposure or suspected exposure of any individual to (a) 5 rems or more to the whole body; (b) 30 rems or more to the skin of the whole body; or (c) 75 rems or more to the hands, forearms, feet or ankles.
- Release or suspected release into the air or water of radioactive material in concentrations greater than 500 times the limits specified in charts showing maximum permissible exposure, averaged over 24 hours.
- A loss of any day or more of the operation of any facilities due to any incident involving any radiation source.
- Damage to property in excess of $1,000 due to any incident involving any radiation source.

30 Day Written Reports to RCB

The State requires a written report within 30 days of the following incidents. The AU and any individual involved shall immediately notify the RSO of the incident and the RSO will provide assistance in preparing the report.

- Exposure of an individual to (a) radiation in excess of, or (b) concentrations of radioactive material in excess of any applicable limit set forth in charts showing maximum permissible exposure.
- Any of the incidents listed above that require immediate reporting.
- Levels of radiation or concentrations of radioactive materials (not involving excessive exposure of an individual) in a non-controlled area in excess of 10 times the applicable limit set forth in Maximum Permissible Exposure.

Each report required shall describe: (a) the extent of exposure of individuals to radiation or radioactive material (b) levels of radiation and concentrations of radioactive material involved; (c) the cause of the exposure, levels or concentrations; and (d) corrective steps taken or planned to assure against recurrence. Radiation reports or inquiries from members of the public shall be referred to the RSO.

16. RADIATION SAFETY PROGRAM RECORDS

A centralized records system is maintained by EHS&RM Radiation Safety for applications for user permits, user authorizations, procurement records, disposal records, inventory records, survey records, program audits, internal surveillances and records of personnel monitoring. The AU must use forms provided by EHS&RM Radiation Safety or an equivalent form to maintain required records.

Examples of several forms and standard records can be found in Appendix A. All forms can be downloaded from the NMSU EHS&RM website under the Radiation Safety Program section or by calling EH&S Radiation Safety at 646-3327. Forms that are available for download or by calling EHS&RM Radiation Safety include:

- Application for Ionizing Radiation Work (Form RS-1). This form must be completed by faculty or senior staff prior to use of radioactive materials or x-ray devices. Please refer to Chapter 4, Permitting, for instructions on how to complete this form.

- Use Permit Modification Form (Form RS-1a) : This form is used by an AU to request a change or modification to an existing RAM or X-Ray permit.

- Emergency Procedure and Contact Information Sign (Form RS-5): These signs are provided by EHS&RM. This information or equivalent must be posted in each laboratory in which activities are being conducted with radioactive materials.

- Radiological Waste Tag (Form RS-6): This tag is to be completed by the AU or a qualified worker and should remain *with the waste* to be disposed. Waste containers must bear this tag to be transported on public roadways. Please refer to Chapter 13, Radioactive Waste Management, for more information on waste types and disposal. EHS&RM will provide these tags to radiological waste generators or departmental stockrooms.

- Contamination Monitoring Report (Form RS-8): The results of the required contamination monitoring of a facility, utilizing swipes or a survey meter, must be recorded. The AU must conduct contamination monitoring periodically (as required by the permit) and submit results to the RSO along with an area map with the semi-annual inventory.

- Unconditional Release (Form RS-10): This form is to be used to record surveys conducted in the process of releasing equipment or facility areas. This form is primarily used by the RSO, but can also be used by the AU. If used by the AU, forward a copy to the RSO when completed.

Examples of forms / records generated by the RSO or EHS&RM Radiation Safety staff includes:

- Radioactive Materials Inventory Report (Form RS-4): This report is prepared by the RSO and sent to each AU for validation or corrections/additions every six months. This report or equivalent information must be returned to the RSO to accurately record the material in inventory under each permit.

- Radioactive Material Package Wipe Test and Usage Logsheet (Form RS-7): This report will be completed by Radiation Safety personnel and forwarded to AU with each package of radioactive material received. This form may also be used to log material use. When the material has been used or disposed, return the completed form to the RSO and your inventory will be updated.

- Permit for Radioactive Material Use (Form RS-2): A permit is issued by the RSO to authorize the use of open sources of radioactive material or sealed radioactive sources. It lists the specific radioisotopes, chemical form and maximum amount of each isotope the AU is authorized to possess. It lists the locations where the materials can be used and stored. The permit also includes special conditions or additional requirements imposed by the RSC when the authorization request was approved.

- Permit for X-ray Device (Form RS-3): A permit is issued by the RSO to authorize use of radiation machines which intentionally produce x-ray. It lists the type of x-ray devices and authorized use locations. The permit also includes special conditions or additional requirements imposed by the RSC when the authorization request was approved.

Many other records are maintained by the EHS&RM Radiation Safety staff to meet the requirements of the Radiation Safety Program, conditions of the Radioactive Material License and CORS, as well as applicable Local, State and Federal Regulations.

Form RS-1: Application for Ionizing Radiation Work

Environmental, Health Safety & Risk Management
New Mexico State University
MSC 3578, Box 30001
Las Cruces, NM 88003-8001

Date Received by EHS&RM____________________ Date Reviewed by RSO ____________________

APPLICATION FOR USE OF RADIOACTIVE MATERIALS

Instructions: Complete all sections as appropriate and submit electronically to the Radiation Safety Officer at dschoep@nmsu.edu and mail signed copy to the RSO at Environmental Health Safety & Risk Management, MSC 3578.

1. Permittee.
List the person who will use or supervise the use of the material or device and be responsible for ensuring that rules and regulations that apply to the use of radioactive materials or devices are followed.

Name	Department	Phone Number	E-Mail Address

2. Permittee Training.
Fill out the following table of training for person submitting application.

Type of Training	Where Trained	Duration of Training	On the Job or Formal
a. Principles and practices of radiation protection			
b. Radioactivity terminology, measurement, standardization and monitoring techniques			
c. Basic mathematics and calculations used in the measurement of radioactivity			
d. Biological effects of radiation exposure			

3. Permittee Experience.
Describe the type and amount of experience the applicant has using radioactive material or devices.

Isotopes / Device	Maximum Amount Used	Where Experience was Gained	Duration of Experience	Type of Use

Page 1 of 6 Revision 06/14/2019

4. Unsealed radioisotopes.

List maximum possession limit desired for each isotope. Maximum amount should include all activity in use, storage and radioactive waste in areas controlled by Permittee. Physical form can be solid, liquid or gas.

Isotope	Physical Form	Chemical Composition	Maximum Amount Needed

5. Sealed Sources.

List maximum possession limit desired for each sealed source. Identify each sealed source by manufacturer, model number, NMSU equipment property number and activity of each isotope. Sources form can be capsule, rod, foil, ECD, etc.

Isotope	Source Form	Manufacturer, Model No., Serial No., NMSU Property No., etc.	Activity (mCi)

6. X-Ray Machines and Other Radiation Producing Devices.

Type of Machine (choose one from list below)	Machine Manufacturer	Machine Model	Control Model No.	Control Serial No.
Number of Tubes	**Tube Serial No.(s)**	**Date Manufactured**	**Date Installed**	**Mode of Use (Fixed or Mobile)**
Max. Rated Spec. (kVp)	**Max. Rated Spec. (mA)**	**Intended Use**		
☐Below 50 ☐50 to 70 ☐Above 70 ☐Other (list)	☐Below 50 ☐50 to 300 ☐Above 300 ☐Other (list)			

Radiation Machine Types (for Box #1)			
1	Analytical Device	10	Fluoroscopy
2	Bone Densitometer	11	Mammography
3	Cabinet X-ray	12	Medical [Radiographic]
4	Combo [above radiographic/under fluoroscopic]	13	Radiography [Industrial]
5	Computed Tomography	14	Radiography [Veterinary]
6	Dental [Intraoral]	15	Veterinary
7	Dental [Multipurpose]	16	X-ray [Diffraction]
8	Dental [Panoramic Cephalometric]	17	X-ray [Fluorescence]
9	Electron Microscope	18	X-ray NDT High Energy Pulse

7. Use and Storage Location.
List all locations where radioactive materials or devices will be stored and used

Location Type	Building Name	Room Number(s)
Storage		
Utilization		

8. Purpose / Protocols
Describe the purpose for which the radioactive material, sealed source or x-ray device will be used. Briefly outline the protocol including information such as estimated quantities of radioactivity to be utilized, proposed use of sealed source and/or x-ray techniques to be employed.

Use additional sheets as needed:

9. Facilities and Equipment
Briefly describe laboratory facilities, fume hoods, special shielding, handling equipment and storage facilities. Please describe any field use of radioactive materials or equipment. Also describe security controls for work whether it is laboratory or field work.

Use additional sheets as needed:

10. Radiation Protection.
a) Describe precautionary methods employed to prevent contamination of personnel and uncontrolled areas.

Use additional sheets as needed:

b) Surveys. List the type and frequency of surveys which will be used to detect possible contamination. How will sealed sources, if any, be leak tested? If you use a portable survey instrument, what is the model and manufacturer? If you share use of a liquid scintillation counter, who has control of it? Where is the survey equipment usually located?

Use additional sheets as needed:

c) Monitoring. Will personnel using the radioactive material or x-ray devices be monitored? If yes, how? If no, include a clear calculation showing that any exposure to personnel will be below the level which requires monitoring.

Use additional sheets as needed:

d) Training. Describe the extent of training and instruction to be conducted for workers supervised by applicant. This should include Radiation Safety offered by EHS&RM and any "in-house" training.

Use additional sheets as needed:

11. Waste Disposal.

Describe potential waste products or residual radioactive materials that will require disposal. Include such items as quantities, concentrations, physical and chemical forms, miscibility with water, and any hazards associated with the waste other than the radioactivity. Request an addendum to authorize sewage disposal of aqueous wastes which will meet the criteria for disposal via sanitary sewer.

Use additional sheets as needed:

12. Shipping / Receiving.

Will you need to ship radioactive materials or sources to another facility? EH&S must be involved in shipping. What manufacturers will you use to procure radioactive materials, sources or x-ray equipment? Describe the procurement method you will use to obtain radioisotopes or equipment. All radioactive materials and sources will be received, checked in and delivered to the lab by EH&S personnel. All shipments must be directed to Environmental Health Safety & Risk Management, EMF Building, 1635 Standley Dr., Las Cruces, NM 88003-8001.

Use additional sheets as needed:

13. Additional Information.

Submit any other information pertaining to the proposed operation which will assure that the program will be conducted in a safe manner and within applicable rules and regulations.

Use additional sheets as needed:

14. Applicant Certification

As a NMSU employee or affiliated worker, I attest that the information contained in this application is accurate and complete. I agree to comply with all requirements pertaining to the safe use, handling, storage, transport and disposal of radioactive materials and radiation machines as outlined in the conditions of my permit and policies of the University Radiation Safety Committee as described in the NMSU Radiation Safety Manual.

I will ensure that authorized users working under my permit have received or will receive adequate safety training including appropriate radiation safety training prior to using the radioactive materials or radiation producing devices under my control. I further attest that these individuals have or will be briefed on emergency procedures, safe laboratory work practices including the safe operation of laboratory equipment prior to performing work.

I will select and provide authorized users working under my permit appropriate personal protective equipment necessary for the safe performance of their work. I will also ensure all necessary administrative and engineering controls are in place and in good working order prior to performing, or authorizing work to be performed under this permit.

I will notify the NMSU Radiation Safety Officer (RSO) in the event of any of the following:

- Any accident that results in inoculation, ingestion and inhalation of radioactive materials, significant external contamination, or any incident that resulted in significant personnel exposures or release of radioactive material to the environment.
- Theft or loss of any radioactive materials / sources or radiation producing devices.
- Prior to leaving employment of New Mexico State University so that a close-out decommissioning inspection of my work area will be conducted by the RSO.

I acknowledge that the University Radiation Safety Committee approval is not transferable to any other NMSU faculty or staff member. I also acknowledge that I will not receive radioactive materials / radiation producing devices from another individual or entity or transfer radioactive materials / radiation producing devices to another individual or entity without prior written approval from the RSO.

I understand that I must submit a written modification request to the RSO whenever there are significant changes to approved experiment protocols / procedures described in the application; change in authorized use or storage locations; changes to approved facilities or facility engineering controls, changes in the type or quantity of radioactive material used, and changes in the users authorized to use radioactive materials or radiation producing devices under my permit.

Applicant Signature: ______________________________ Date: __________________

University Radiation Safety Committee Member Signature - Approving Permit #: ________________

RSC ____ Date: ________________

RSC ____ Date: ________________

RSC ____ Date: ________________

RSC ____ Date: ________________

RSC ____ Date: ________________

RSO ____ Date: ________________

Form RS-1A: Example Permit Modification Request Form

Environmental Health Safety & Risk Management
New Mexico State University
P.O. Box 30001 / MSC 3578
Las Cruces, NM 88003-8001
Phone: 575-646-3327 Fax: 575-646-7898

RADIATION PERMIT MODIFICATION FORM

Instructions: Fill out the appropriate section(s) of the form and send the signed form and any supplemental information via campus mail to EHS&RM, MSC 3578 or scan the signed form and e-mail it to dchoep@nmsu.edu.

Permit Holder Name:______________________ Permit Number__________

Signature:______________________ Submission Date__________

Changes / Modifications to an Existing Permit

☐ Add Personnel to Permit:______________________
(List new personnel & attach training and experience record form)

☐ Remove Personnel from Permit:______________________
(List personnel to be removed)

☐ Add New Laboratory to Permit:______________________
(RSO inspection is required) (Building Name / Room Number)

☐ Remove a Laboratory from Permit:______________________
(RSO Inspection is required) (Building Name / Room Number)

☐ A substantial change(s) to the University Radiation Safety Committee (URSC) approved application (change to approved scope of work, addition of new isotopes or radiation producing devices, etc.):

- Contact the RSO and send a brief description of the modification. The type of documentation and level of review needed by the URSC varies depending on the type and complexity of the requested modification. (The *RSO will contact the appropriate URSC member(s) and they will conduct a preliminary review. The goal of the preliminary review is to determine the type of formal documentation and level of URSC review that will be needed to evaluate the request.*

Change in the Status of an Existing Permit

☐ Change Permit Holder:
New Permit Holder Name: ______________________
(New permit holder must submit a new RAM Use Application)

☐ Temporarily Inactivate Permit (i.e. sabbaticals, not using RAM for an extended period of time):
To place a permit on "Inactive" status the following conditions must be met:

1. Permit Holder has no radioactive material in inventory, storage or waste
2. After Condition 1 has been met; the RSO has conducted a laboratory contamination survey or has a recent laboratory survey on file.

☐ Terminate Permit: *Permitted laboratories must be inspected, decommissioned and certified as "clean" by the RSO before the permit can be terminated.*
- ☐ Terminate only activities using radioactive material or radioactive devices
- ☐ Terminate all laboratory activities: *(Follow EHS&RM Procedure for Decommissioning of Laboratories)*

☐ Other: (Permit change / modification not listed above)

- Attach a detailed description of the requested permit change / modification to this form.

Radiation Permit Modification Form Page 1 of 1 Rev. 5/19

Form RS-2: Example Radioactive Material Use Permit

FORM RS-2 (Revised 05/19)

PERMIT FOR RADIOACTIVE MATERIALS
NEW MEXICO STATE UNIVERSITY

Permit No.

Review Date :

Expiration Date :

In reliance on statements made by the applicant, a permit is hereby issued authorizing the applicant to receive, acquire, own, possess, and transfer radioactive material below, and to use such material for the purpose(s) and at the place(s) designated. This permit is subject to all applicable rules, regulations, and orders of the appropriate governing agencies, NMSU, University Radiation Safety Committee and the Radiation Safety Officer.

1. Name:

   Dept:

   Phone:

2. Authorized Locations

Isotope	License Citation	Manufacturer	Model	Serial umber	NMSU Source ID	Source Activity (mCI)

6. Conditions -

Unless otherwise specified, the authorized places of use are as stated above. All rules, regulations, and conditions contained in the State of New Mexico Environment Department Radiation Protection Regulations 20.3 NMAC, New Mexico State University License, and the New Mexico State University Radiation Safety Manual will apply.

Approval Date: ______________________

By: ______________________________________

Radiation Safety Officer

Example Form RS-2 Sewage Disposal Addendum to Permit

NMSU Requirements for Sewage Disposal of Aqueous Waste Contaminated with Radioactivity as Authorized on Permit RS-2

1. Written authorization to dispose via the sewer must be noted on the AU Use Permit
2. AU must monitor disposal activity to ensure all criteria are met.
3. AU must clearly mark one sink "Caution Radioactive Material" for sewage disposal and restrict facilities personnel from working on such sink until surveyed and cleared of potential contamination.
4. AU must that the monthly maximum and concentration limits for materials disposed of through the sanitary sewer system must not exceed the limits specified in Table 13.1 below. For isotopes not listed, the RSO will provide the allowable release limit.
5. The material must be readily soluble or readily dispersible biological material in water and not otherwise regulated as hazardous or toxic.
6. AU must accurate records of all sewerage disposals will be maintained and submitted to the RSO on the semiannual Radioactive Materials Inventory (Form RS-6).

Limits for Sewage Disposal of Soluble Radioactivity in Aqueous Waste

Isotope	Maximum Monthly Sewer Disposal per AU[1]	NMSU Monthly Average Concentration Allowable in Sewer Water[2] (μCi/mL)
	μCi	
^{3}H	800	$1x10^{-2}$
^{14}C	170	$3x10^{-4}$
^{32}P	170	$9x10^{-5}$
^{35}S	170	$1x10^{-3}$
^{45}Ca	170	$2x10^{-4}$
^{125}I	170	$2x10^{-5}$
All Uranium	170	$3x10^{-6}$

[1] Maximum allowable monthly quantity of drain disposed isotope per authorized Permit (based on 50 AUs x 10%)
[2] Maximum allowable monthly concentrations if diluted by the lowest average monthly quantity of sewage (8.1×10^{6} gallons) released into the sewer by the licensee, specified in 20 NMAC 3.1, Subpart 4, Appendix B, Table III

Sewage Disposal Log

Date	Isotope	Material Description	Total Activity (μCi)	Disposer's Initials

Example Radioactive Material Laboratory Door Sign

Form RS-4: Example Radioactive Material Inventory Report

New Mexico State University
Environmental Health & Safety
MSC 3578
ph. 646-3327
fax 646-7898

MEMORANDUM

TO: Pistol Pete
Envir. Health and Safety

FROM: Environmental Health & Safety

DATE: August 22, 2011

RE: Directions to complete the RS-4 Radioactive Materials Inventory Report

In order to keep our records as up to date as possible, please take a moment and review all the information on the attached "RS-4 Radioactive Materials Inventory Report". These forms contain the most recent information the EH&S has for your laboratory. Please note any changes directly on the forms and return with your signature and date to the EH&S on or before 09/21/2011.

To facilitate your review of the attached forms, we have identified the major concerns for each section:

Section 1. PERMITTEE INFORMATION:
Are the names and phone numbers listed here current?

Section 2. NUCLIDE INVENTORY QUANTITIES
This section shows each individual radionuclide we show that you have on hand. Is this accurate? Cross out the radionuclides you no longer have on hand and return the completed usage log (RS-7) as the nuclide has been expended.

Section 3. LABORATORY PERSONNEL:
Is this an accurate listing of the personnel currently working with radioactive material in your lab?

Section 4. AUTHORIZED RADIOACTIVE MATERIAL LAB LOCATIONS:
Is this a comprehensive and accurate listing of all the locations where your sources of radiation are used or stored?

Section 5. SURVEY METERS:
Is this the survey meter that is currently in use?

Section 6. AUTHORIZED SEWERAGE DISPOSAL:
Complete only if you are authorized to dispose liquids via the sanitary sewer system.

Your prompt attention to this authorization review is greatly appreciated. If our office can provide any assistance during your inventory, please call us at 646-3327.

This inventory is Correct / Not Correct (circle one). If inventory is not correct, you must include supporting documentation with this inventory and return to the Environmental Health and Safety Department.

Signature: ______________________________ Date: ______________________

RS-4 RADIOACTIVE MATERIAL INVENTORY REPORT

SECTION 1: PERMITTEE INFORMATION

Permittee : **Pete, Pistol**
Department: **Envir. Health and Safety**
Office Phone: **(575)646-3327**
Lab Phone: **(575)646-1023**
Fax: **(575)646-5898**
E-Mail: **dschoep@nmsu.edu**

Alternate: **David Schoep**
Phone: **(575)646-1023**
E-Mail: **dschoep@nmsu.edu**

Inventory Date: **08/22/2011**
Permit Number: **R-PETE**
Permit Expires: **09/30/2014**
Page Number: **1**

SECTION 2 : NUCLIDE INVENTORY & QUANTITIES

Nuclide	Compound	Possession Limit	Per Order Limit
H-3	Any	10.00000	0.00000
C-14	Any	10.00000	0.00000

Isotope : C-14 **A** **R-PETE**

On Hand Amount : 0.00000 mCi
Possession Limit : 10.00000 mCi
Available to Purchase : 10.00000 mCi

I agree with the balances shown for this isotope. ______ initial

Isotope : H-3 **C** **R-PETE**

On Hand Amount : 0.00000 mCi
Possession Limit : 10.00000 mCi
Available to Purchase : 10.00000 mCi

I agree with the balances shown for this isotope. ______ initial

SECTION 3 : LABORATORY PERSONNEL

Employee Name		Type	Dosimetry Extremity	Dosimetry Whole	Dosimetry None	Training History		
Pete	Pistol	PH	☐	☑	☐	08/22/2011	RADSAF	NMSU Radiation Safety
Schoep	David	RSO	☐	☑	☐	08/01/2006	EXMPT	Instructor

GDS=Grad Student UNS=Unspecified UGR=Undergraduate TEC=Technician TMP=Temporary
SPC=Specialist PH= Permit Holder FAC =Faculty STF=Staff

SECTION 4 : AUTHORIZED RADIOACTIVE MATERIAL LAB LOCATIONS

Building	Room/Lab	Phone	Primary	Type
WIND TUNNEL/RESEARCH BUILDING	112		☑	Waste Management Unit

SECTION 5 : SURVEY METERS

Manufacturer	Model	Serial #	Display	Calibration Expires
Ludlum	1234	EXAMPLE	mR/hr	08/22/12

SECTION 6 : AUTHORIZED SEWAGE DISPOSAL

Sewage disposal during this inventory period (check) ☐ yes ☐ no

If yes, indicate isotope ______________ and total activity disposed of in mCi ___________.

Note : Disposal start date is deadline of last inventory cycle. End date is receipt date of this inventory checklist.

Example Form RS-5: Emergency Response Procedures for Radionuclides

EMERGENCY PROCEDURES FOR RADIOACTIVE MATERIAL

(1 of 2)

LARGE SPILL

A spill of greater than 100 µCi of any radionuclide, or a large spill on the floor or where personnel are contaminated.

1. Immediately notify all persons in the area that you have had a spill of radioactive material.

2. Notify all persons not involved in the spill to vacate the room. Be sure to survey all individuals as they leave the room. Especially important is to survey the soles of the shoes worn by these individuals to assure that the spill has been contained within the room and is not spread outside of the room. Also survey hands, lab coats, and other clothing. Contaminated clothes put into plastic bag.

3. Prevent the spread of contamination by covering the spill with absorbent paper and by limiting the movement of all personnel who may be contaminated.

4. Shield the source if necessary. This should be done only if it can be done without further spread of contamination or a significant increase in radiation exposure.

5. Report the incident to the Radiation Safety Officer by phone. If after hours or on a weekend, contact the Radiation Safety Officer through the NMSU Dispatcher. This applies 24 hours a day, 7 days a week.

6. Prevent unauthorized entry by closing the door to the room and placing a "Caution: Contaminated Area" sign or warning tape across the entrance. If possible, an individual who is not contaminated should be stationed outside of the door to prevent unauthorized entry until the spill is cleaned up.

7. Decontaminate personnel immediately if individuals are contaminated, following procedures for personnel decontamination on page 2.

8. Clean up the spill using appropriate protective apparel (disposable gloves, shoe covers, lab coat, eye protection, and respirator if necessary) and absorbent pads. Carefully fold absorbent paper with clean side out and place in plastic bag for transfer to a radioactive waste container. Also put contaminated gloves and any other contaminated disposable material in the bag.

9. Survey the area using an appropriate radiation detector-survey meter or liquid scintillation counter. Check the area around the spill. Also check your hands, clothing, and shoes for contamination.

10. Document all survey results and cleanup efforts in a written report. **Forward a copy of the written report to the Radiation Safety Officer.** Keep a copy of the written report on file with the laboratory Radiation Safety Survey Records.

EMERGENCY TELEPHONE NUMBERS

Radiation Safety Officer David Schoep	646-1023 (office) 312-6649 (cell)
Environmental Health & Safety	646-3327
Police or Fire Non-Emergency Dispatcher	**911 (Emergency)** 646-3311
Memorial Medical Center	522-8641
NM Environment Dept. 24 Hour Emergency	(505) 827-9329

FIRE in the event of a general fire in the laboratory

1. Call 911 and report fire emergency. Report the hazards that are present such as radioactive materials, chemicals, compressed gas.

2. Utilize available firefighting equipment to control or extinguish small fires that can be safety handled prior to arrival of the fire department.

3. Report the incident to the Radiation Safety Officer by phone. If after hours or on a weekend, contact the Radiation Safety Officer through the NMSU Dispatcher. This applies 24 hours a day, 7 days a week.

FORM RS-5 (rev. Feb 2013)

EMERGENCY PROCEDURES FOR RADIONUCLIDES

PERSONNEL DECONTAMINATION

Promptly decontaminate personnel by taking the steps listed below, using appropriate containers to collect waste materials generated during the decontamination process.

1. Notify the Radiation Officer immediately by phone. If after hours or on a weekend, contact the Radiation Safety Officer through the NMSU Dispatcher. This applies 24 hours a day, 7 days a week.

2. Remove contaminated clothing and place in a plastic bag

3. Flush contaminated skin with lukewarm water.

4. Wash contaminated skin with a mild soap and lukewarm water. Use of a small sponge or soft brush (e.g., complexion brush) may be helpful. Avoid irritating the skin. Repeat steps 2 and 3 as necessary.

5. Monitor for contamination after each series of washing and rinsing to determine the effectiveness of the decontamination efforts.

6. If fingernails or fingertips are contaminated, clip nails as short as possible, and repeat 2,3, & 4.

7. If contamination persists, induce perspiration by covering the area with plastic (e.g. place a latex or vinyl glove over a contaminated hand, and tape opening at wrist). Then wash the affected area again to remove any contamination that was released by the perspiration.

8. Terminate decontamination efforts when:
   a. All radioactive contamination has been removed; or
   b. The surveys following each of several successive decontamination steps indicate that contamination levels are no longer decreasing; or
   c. Erythema (reddening of the skin) has occurred.

RELEASE OR LOSS OF RADIOACTIVE MATERIAL

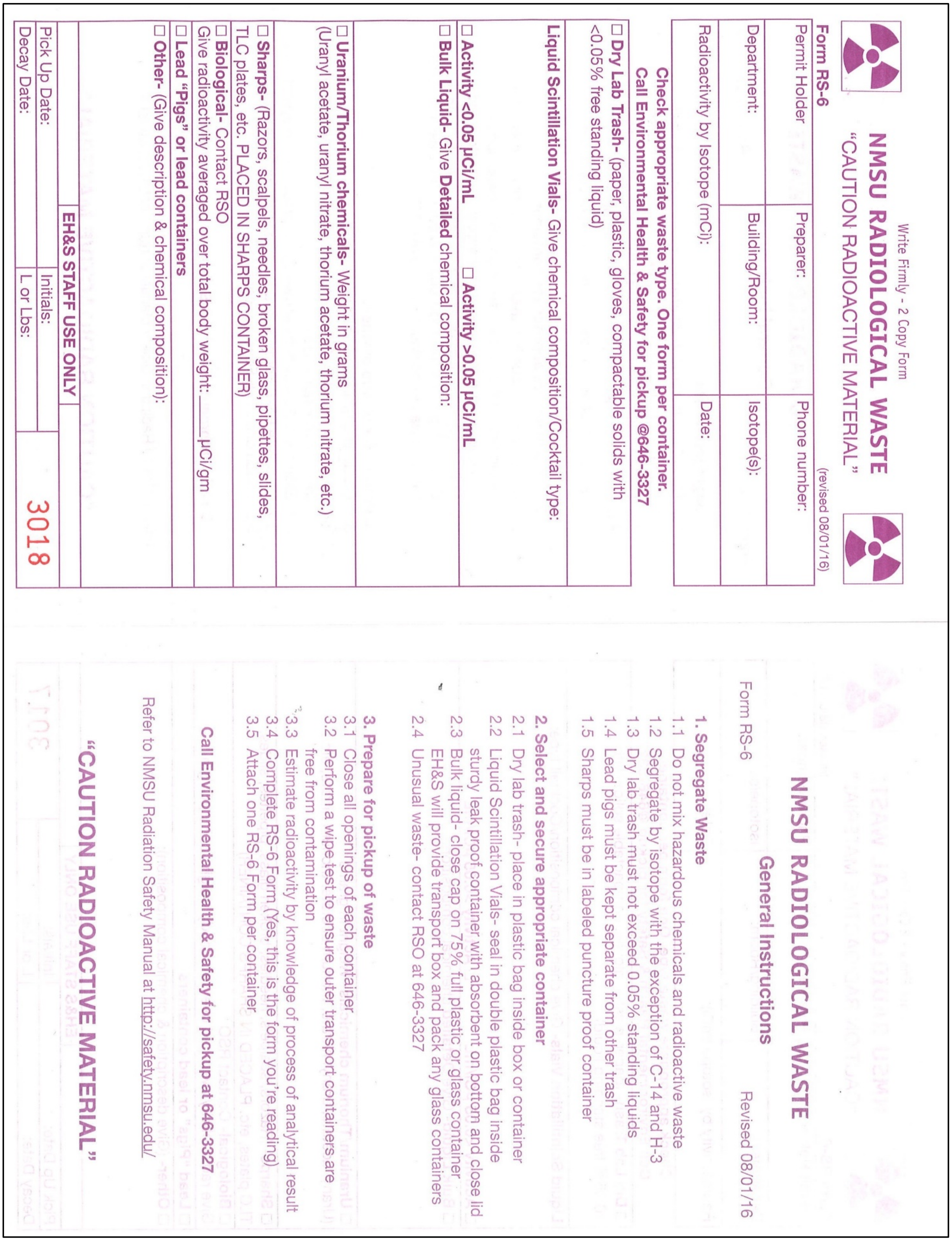
In the event that radioactive materials are released to the environment or discovered missing, notify the Radiation Officer immediately by phone. If after hours or on a weekend, contact the Radiation Safety Officer through the NMSU Dispatcher. This applies 24 hours a day, 7 days a week. The Radiation Safety Officer will provide guidance and assistance specific to the situation.

SPILL RESPONSE KIT CONTENTS:

It is the responsibility of each permit holder to maintain essential decontamination supplies in his/her laboratory. Supplies should include the following:

	i. absorbent pads - (disposable)
	j. absorbent towels (disposable)
	k. mild soap (e.g. Joy or hand soap, suitable for skin decontamination)
	l. small soft brush (suitable for skin decontamination, e.g. complexion brush)
	m. small sponge (suitable for skin decontamination)
	n. gloves (disposable and heavy duty)
	o. shoe covers (disposable)
	p. heavy duty plastic bags for collecting used absorbent materials, etc.
	q. scouring pad, disposable mop, broom and dust pan
	j. decontaminating solutions (e.g. Radiac-Wash, Rad-Con, Count Off, etc.)
	k. tape ("Caution: Radioactive Materials" or "Caution: Contaminated Area")
	l. signs ("Caution: Contaminated Area")

Example Form RS-6: Radiological Waste Tag



Write Firmly - 2 Copy Form

NMSU RADIOLOGICAL WASTE

"CAUTION RADIOACTIVE MATERIAL"

Form RS-6 (revised 08/01/16)

Permit Holder	Preparer:	Phone number:
Department:	Building/Room:	Isotope(s):
Radioactivity by Isotope (mCi):		Date:

Check appropriate waste type. One form per container.
Call Environmental Health & Safety for pickup @646-3327

☐ **Dry Lab Trash-** (paper, plastic, gloves, compactable solids with <0.05% free standing liquid)

Liquid Scintillation Vials- Give chemical composition/Cocktail type:

☐ **Activity <0.05 µCi/mL** ☐ **Activity >0.05 µCi/mL**

☐ **Bulk Liquid-** Give **Detailed** chemical composition:

☐ **Uranium/Thorium chemicals-** Weight in grams
(Uranyl acetate, uranyl nitrate, thorium acetate, thorium nitrate, etc.)

☐ **Sharps-** (Razors, scalpels, needles, broken glass, pipettes, slides, TLC plates, etc. PLACED IN SHARPS CONTAINER)

☐ **Biological-** Contact RSO
Give radioactivity averaged over total body weight: ____ µCi/gm

☐ **Lead "Pigs" or lead containers**

☐ **Other-** (Give description & chemical composition):

EH&S STAFF USE ONLY		
Pick Up Date:	Initials:	3018
Decay Date:	L or Lbs:	

Form RS-6 Revised 08/01/16

NMSU RADIOLOGICAL WASTE

General Instructions

1. Segregate Waste

1.1 Do not mix hazardous chemicals and radioactive waste
1.2 Segregate by isotope with the exception of C-14 and H-3
1.3 Dry lab trash must not exceed 0.05% standing liquids
1.4 Lead pigs must be kept separate from other trash
1.5 Sharps must be in labeled puncture proof container

2. Select and secure appropriate container

2.1 Dry lab trash- place in plastic bag inside box or container
2.2 Liquid Scintillation Vials- seal in double plastic bag inside sturdy leak proof container with absorbent on bottom and close lid
2.3 Bulk liquid- close cap on 75% full plastic or glass container EH&S will provide transport box and pack any glass containers
2.4 Unusual waste- contact RSO at 646-3327

3. Prepare for pickup of waste

3.1 Close all openings of each container
3.2 Perform a wipe test to ensure outer transport containers are free from contamination
3.3 Estimate radioactivity by knowledge of process of analytical result
3.4 Complete RS-6 Form (Yes, this is the form you're reading)
3.5 Attach one RS-6 Form per container

Call Environmental Health & Safety for pickup at 646-3327

Refer to NMSU Radiation Safety Manual at http://safety.nmsu.edu/

"CAUTION RADIOACTIVE MATERIAL"

Example Form RS-7 Radioactive Material Package Wipe Test and Usage Log

New Mexico State University

Environmental Health and Safety

FORM RS-7 RADIOACTIVE MATERIAL PACKAGE WIPE TEST AND USEAGE LOG SHEET

Authorized User:	Tracking/Inventory #:
Lot Number:	P.O. Number:
Receipt Date:	Radionuclide:
Lab Contact:	Compound:
Contact Phone:	Number of Containers:
Vendor:	Activity/Containerl (mCi):

Package Receipt Survey Results;

Wipe Test Instrument: Make Model: Serial #:

Package Wipe Test: dpm/100 cm^2 Vial Wipe Test: dpm

DOT Labeling:

Survey Instrument: Make Model: Serial #:

Package Surface Reading: mR/hr Comments:

Container Disposal Record/Useage Record

Used By	Date	Activity Removed(mCi)	Dry Decay Storage	Dry Non Decay	Aqueous Liquid	LSC EQ	LSC Vials	Other (explain)

When isotope is expended, return this sheet to EH&S at MS 3578, attn: RSO.

Signature : ____________________ Date/Time : ____________

Example Form RS-8 Example Contamination Monitoring Report

FORM RS-8 (revised 05/05)

CONTAMINATION / AREA SURVEY REPORT

Date:	Time:	Location:
Surveyor:		Reviewed by:
Purpose of Survey:		

Instruments Used				
Model No:	Serial No:	Calibration Date	Efficiency	Background Reading
1.				
2.				

Item or Location	Dose Rate mR/hr	Contamination CPM or DPM		Swipe Result in disintegrations per minute
		Alpha	Beta/Gamma	
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Sketch Item or Map Area:

Example Form RS-10: Example Survey Record for Unconditional Release

FORM RS-10 (Revised 8/05)

SURVEY RECORD FOR UNCONDITIONAL RELEASE

Permittee:	Isotopes Permitted				
Name:	Max. Quantity (mCi)				
Date:	Surveyor:				

AREA OR DEVICE

Building:	Room/Area:
Equipment Description:	

SURVEY METER RESULTS

Instrument:	Calibration Date:	Background:
Type	Measurement and Unit	Comments:

SWIPE TEST RESULTS

Instrument:	Calibration Date:	Avg. background:
Location	Results	Comments:
Map Attached: Y N	Swipe Report Attached: Y N	

According to the results indicated above, these areas are decommissioned and released for unrestricted use.

____ ____________________

Radiation Safety Officer Signature Date

Example RS-12 Bill of Lading for Nuclear Gauge Field Use

FORM RS-12 (Revised 8/11)

RADIOACTIVE MATERIALS

Bill of Lading

OWNER: ______________________________ (print name)

______________________________ (dept. or office)
New Mexico State University
PO Box 30001 MSC ________________
Las Cruces, New Mexico 88003-8001

PHONE: (575) ____________________

EMERGENCY ASSISTANCE:
New Mexico Environment Department Emergency (24 hour): 505-827-9329
NMSU 24-hour Emergency Number: 575-646-3311 (ask to contact RSO)
New Mexico State University RSO: 575-646-3327, 575-646-3311 (after hours)

INSTRUMENT MANUFACTURER, MODEL NUMBER:
____

SERIAL NUMBER:______________
NMSU NUMBER:______________

PROPER SHIPPING NAME:
Radioactive Material Type A Package Special Form
Non-fissile/Fissile Excepted UN 3332 RQ

RADIONUCLIDE (special form):__________________

ACTIVITY: __________ (mCi) __________ (GBq)

CATEGORY OF LABEL APPLIED: ______________

TRANSPORT INDEX: TI = __________________

PACKAGE TYPE: Type A

DIMENSIONS: ______________ (cm. or in.)

"Shipper certifies that the above named materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation."

______________________________ (RSO or Shipper's signature)

Example Form NMED 045 Notice to Employees

State of New Mexico

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION
(20.3.4 NMAC)
NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS: INSPECTIONS
(20.3.10 NMAC)

Environment Department

YOUR EMPLOYER'S RESPONSIBILITY
Your employer is either licensed or registered to utilize sources of radiation in accordance with the New Mexico Radiation Protection Regulations (20.3 NMAC).

Your employer is required to:

- Apply the regulations to work involving sources of radiation.
- Post or make available to you a copy of the regulations, license, and operating procedures that apply to work you are engaged in, and explain their provisions to you; post Notices of Violation involving radiological working conditions and orders.

If a company violates the requirements, it can be fined or have its license modified, suspended or revoked.

YOUR RESPONSIBILITY AS A WORKER
You should familiarize yourself with those provisions of the regulations and the operating procedures that apply to the work you do. You should observe their provisions for your own protection and the protection of your co-workers. If you observe a violation, you should report it.

REPORTS ON YOUR RADIATION EXPOSURE HISTORY
[20.3.10.1003] If requested, your employer must, within 30 days:

- Notify you of exposures in excess of any dose limits in 20.3 NMAC,
- Advise you of your dose annually, and
- Give you a written report of your radiation exposure upon termination of your employment.

INSPECTIONS
All licensed and registered activities are subject to inspection by representatives of the Environment Department. During inspections, Department inspectors may confer privately with workers. During the course of an inspection, any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which the worker has reason to believe may have contributed to or caused any violation. A worker, or representative of workers, may request an inspection by sending a signed notice of the alleged violation of the Act, regulations, or license condition.

CONTACTING THE RADIATION CONTROL BUREAU
You can contact the Radiation Control Bureau of the New Mexico Environment Department at the address and phone number listed below:

RADIATION CONTROL BUREAU
1100 St. Francis Drive, Suite 2022
Mail to: P.O. Box 5469
Santa Fe, NM 87502-5469
Telephone (505) 476-8600
Fax (505) 476-8654

REGULATIONS
Title 20.3 NMAC is available on the internet web page:
https://www.env.nm.gov/nmrcb/home.html

24 / 7 EMERGENCY NUMBER: 911 or NMDPS (505) 827-9329

NMED 045 Revised 3/2016	POSTING REQUIRED	Copies of this notice must be posted in a sufficient number of places to permit employees working in or frequenting any portion of a restricted area to observe a copy.

https://www.env.nm.gov/nmrcb/documents/NMED045_08.pdf

Appendix B RADIOTOXICTY AND FACILITY LIMITATIONS

The following tables are taken from US NRC Regulatory Guide NUREG-1556, Vol. 11; *Consolidated Guidance about Materials Licenses: Program-Specific Guidance about Licenses of Broad Scope*, Final Report (1999). The table Radionuclides Classified According to Relative Toxicity, excerpted from IAEA Safety Standard, Safety Series 1, "Safe Handling of Radionuclides, 1973 Edition" is not all inclusive and is meant to be used as an example only. Based on chemical/physical form, need and quantities, your classification scheme may differ from that of the IAEA excerpt.

Radionuclides Classified According To Relative Radiotoxicity

(Excerpted from IAEA Safety Standard, Safety Series No. 1, "'Safe Handling of Radionuclides, 1973 Edition")

Radiotoxicity of Radionuclides	Radionuclides
1: Very High Radiotoxicity	^{210}Pb ^{226}Ra ^{227}Th ^{231}Pa ^{233}U ^{238}Pu ^{243}Am ^{244}Cm ^{249}Cf ^{210}Po ^{228}Ra
2: High Radiotoxicity	^{22}Na ^{56}Co ^{95}Zr ^{125}Sb ^{131}I ^{144}Ce ^{181}Hf ^{207}Bi ^{228}Ac ^{36}Cl ^{60}Co ^{125}I ^{192}Ir ....
3: Moderate Radiotoxicity	^{7}Be ^{48}Sc ^{65}Zn ^{91}Sr ^{103}Ru ^{125m}Te ^{140}La ^{153}Gd ^{187}W ^{198}Au ^{14}C ^{48}V ^{69m}Zn ^{90}Y ^{32}P ^{35}S ^{51}Cr ^{24}Na ....
4: Low Radiotoxicity	^{3}H ^{58m}Co ^{71}Ge ^{87}Rb ^{97}Nb ^{103m}Rh ^{131m}Xe ^{125}Cs ^{191m}Os ^{232}Th ^{15}O ^{85}Kr ^{99m}Tc

Limitations on Activities in Various Types of Working Places or Laboratories

Radiotoxicity of radionuclides	Minimum quantiity µCi	Type of working place or laboratory required		
		Type C	Type B	Type A
1: Very High	0.1	<10 µCi	10 µCi-10 mCi	10 mCi or more
2: High	1.0	<100 µCi	100 µCi-10 mCi	100 mCi or more
3: Moderate	10	<1 mCi	1 mCi-1 Ci	1 Ci or more
4: Low	100	<10 mCi	10 mCi-10 Ci	10 Ci or more

NOTE: Laboratory types correspond to the laboratory classification criteria of IAEA Safety Standard, Safety Series No. 1. Type C is a good-quality chemical laboratory. Type B is a specially designed radioisotope laboratory. Type A is a specially designed laboratory for handling large activities of highly radioactive materials. In the case of a conventional modern chemical laboratory with adequate ventilation and nonporous work surfaces, it may be possible to increase the upper limits of activity for Type C laboratories toward the limits for Type B for toxicity groups 3 and 4.

APPENDIX C FUNDAMENTALS OF RADIOACTIVITY

Components of an Atom

The basic components of the atom are the proton, neutron and the electron. The positron or antielectron is important in PET (Positron Emission Tomography) studies but is not a common atomic particle. The particular combination of protons and neutrons determines not only what the element is but also which isotope of the element is present. The number of protons determines the identity of the element, and the number of neutrons determines the isotope of that element. Atoms are radioactive when there is an unstable nucleus with an excess of energy.

Radioactive Decay

Atoms are radioactive because the ratio of neutrons to protons is not ideal. Through radioactive decay, the nucleus approaches a more stable neutron to proton ratio. Radioactive decay release different types of energetic emissions. The three most common types of radioactive emissions are alpha particles, beta particles, and gamma rays. X-rays differ from gamma rays only in how they are produced in the atom. X-rays are atomic phenomena whereas gamma rays are nuclear phenomena, but the two are indistinguishable once they have left the atom. Several other types of radioactive decay exist: fission, positron decay, and electron capture. These processes are not generally encountered in the laboratory environment and will not be discussed in this text.

- *Alpha decay* occurs when the neutron to proton ratio is too low. Alpha decay emits an alpha particle, which consists of two protons and two neutrons. This is the same as a helium nucleus and often uses the same chemical symbol ^{4}He. Alpha particles are highly ionizing (e.g. deposits energy over a short distance). Since alpha particles lose energy over a short distance, they cannot travel far in most media. For example, the range of a 5 MeV alpha particle in air is only 3.5 cm. Consequently, alpha particles will not normally penetrate the outermost layer of the skin. Therefore, alpha particles pose little external radiation field hazard. Shielding of alpha particles is easily accomplished with minimal amounts of shielding. Examples of alpha particle emitting radionuclides include ^{238}U, ^{239}Pu, and ^{241}Am.

- *Beta decay* occurs when the neutron to proton ratio is too high. The radioactive nucleus emits a beta particle, which is essentially an electron, in order to bring this to a more Beta particles are less ionizing than alpha particles. The symbol for a beta particle is β. The range of beta particles depends on the energy, and some have enough to be of concern regarding external exposure. A 1 MeV beta-particle can travel approximately 12 feet in air. Energetic beta particles can penetrate into the body and deposit dose to internal structures near the surface. Since beta particles are less ionizing than alpha particles, different types of shielding is required. For example, ^{32}P can be effectively shielded by 1/4 to 3/8 inches of Plexiglas. It is important to shield beta particles with low z materials (e.g. aluminum or acrylic) to prevent x-ray emissions as the electrons slow down.

- *Gamma rays* are not particulate radiation like the alpha and beta, but a form of high-energy electromagnetic wave. Gamma-rays are the least ionizing of the three forms discussed. In fact, gamma-rays are only an indirect form of ionizing radiation. This means that gamma rays must interact with the atoms in the material first, and these interactions create charged particles. A 1 MeV gamma-ray can travel an average of 130 meters in air. Since gamma radiation can travel far in air, it poses a significant external radiation hazard. Further, if ingested, it may pose an internal radiation hazard. Shielding of gamma-rays is normally accomplished with high atomic number materials such as lead.

Units

There are several different units used to describe the amount of radioactivity or radiation exposure. Refer to Appendix F for a Unit Conversion Table examples of these units.

Units of Activity

The “amount” of radioactivity can be described using several different units including curie (Ci), Becquerel (Bq), disintegration per second (dps) or disintegration per minute (dpm).

- ❖ The international system of units (SI) unit is the Becquerel (Bq) which is equivalent to 1 dps.
- ❖ The historic predecessor of the Bq is the curie (Ci) which is still in common use in the US.

1 Ci = $3.7\text{x } 10^{10}$ Bq

These units describe the "amount" of the radioactivity or the number of radiations emitted per unit of time but do not account for any of the properties of the type radiation emitted. For example, 250 µCi is considered a relatively small amount activity, while 250 Ci is a very large amount activity. To describe the degree of hazard to people from a particular radiation other units and measures are needed.

Units of Exposure, Absorbed Dose and Dose Equivalent Roentgen

The roentgen, R, is a unit of exposure. This unit is only appropriate for electromagnetic radiation (e.g. gamma rays and X-rays), it does not apply to alpha and beta particles. The roentgen is the measure of ion pairs created in air. One roentgen is equal to 1 electrostatic unit (esu) per cubic centimeter of air at standard temperature and pressure (STP, 0^{o}C = 273 K on the absolute temperature scale and 760 torr, 1 torr = 1 mm Hg). The new SI convention for the measure of exposure is the coulomb per kilogram of air, C/kg.

1 R = 1 esu/cm^3 = 2.58 x 10-4 C/kg air
= 2.083 x 10^{9} ion pairs/cm^3

This unit gives some information about the type and "strength" of the radiation field but is still vague regarding damage or risk to humans and materials.

Absorbed Dose

The rad is an acronym for radiation absorbed dose. It is a measure of the amount of energy deposited in a material per gram of the material. Specifically, one rad is equal to one hundred ergs of energy deposited in 1 gram of material. The SI unit for absorbed dose is the gray (Gy)

1 rad = 100 erg/gm = 0.01 Gy 1
rad = 0.876 R for γ and X-rays
1Gy = 100 rad

In many radiation protection calculations, one rad is approximately equal to one roentgen. However, more accuracy is required in radiation therapy applications. The rad measures energy deposited per unit mass of a material by a particular type of radiation. This relates the amount of damage that may be done to a living organism by the radiation, but does not account for different ionizing capabilities of radiation types (i.e. gamma versus alpha).

Dose Equivalent

The dose equivalent (rem or sievert) takes into account the risk of damage to living tissue from different types of radiation with varying characteristics (energy, type, stopping power, etc.). Specifically, the rem is a rad multiplied by a quality factor (Q). The SI unit for dose equivalent is the Sievert (Sv). 1 Sv = 100 rem.

The quality factor depends of the type and energy of the radiation (i.e. alpha, neutron, gamma). The radiation protection regulations establish the following quality factors.

QUALITY FACTORS (Q)	
Type of Radiation	Quality Factor
X, gamma, or beta radiation and high-speed electrons	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge	20
Neutrons of unknown energy	10
High-energy protons	10

Dose equivalent is the unit which is most important in radiation safety. All legal doses in radiation protection are recorded in rem or Sv.

Half-life

Since radioactive atoms decay, the number of radioactive nuclei in a finite sample decreases with time. This decay obeys a logarithmic decay that can be expressed by the equation,

$$A = A_o e^{-\lambda t}$$

where A_o is the initial activity, λ is the decay constant, and *t* is the time. The decay constant is a physical property of that radionuclide and does not change. The decay constant basically measures the probability that a nucleus will decay in one second. The bigger the decay constant the more probable the nucleus will decay in one second. A useful parameter to describe how long an isotope will last is the half-life, $t_{1/2}$. The half-life is the time it takes for a sample of radioactive atoms to decay to one-half of the initial value. After one half-life there is only ½ as much as at the start. After two half-lives there is (½)(½) = 1/4 as much left as at the start. The half-live and decay constant are related by the simple equation:

$$t_{1/2} = 0.693/\lambda$$

As an example, ^{32}P has a half-life of about 15 days. Determine how much of a 50 µCi sample is left after a month and a half. This can be done by substitution into the above equations, or easily estimated as follows. 1.5 months = 45 days, $t_{1/2}$ = 15 days; therefore, 45 days = 3 half-lives.
After one half-life there is (0.5)(50 µCi) = 25 µCi
After two half-lives there is (0.5)(25 µCi) = 12.5 µCi
After three half-lives there is (0.5)(12.5 µCi) = 6.25 µCi or
(50 µCi)(0.5)(0.5)(0.5) = 6.25 µCi

The important concept here is that radioactive samples decay with time. Many of the isotopes commonly used in lab experiments have short half-lives, and will decay to low levels in a few months.

Half-Life of Common Laboratory Radioisotopes	
Radioisotope	Half-Life
P-32	14.3 days
S-35	87.2 days
I-125	60.1 days
H-3	12.3 years
C-14	5730 years

Inverse Square Law

An important concept for reducing exposure to radiation is the inverse square law. This states that as the distance away from a radiation source increases, the intensity decreases as the square of the distance. Moving twice as far away from a source reduces the exposure by a factor of 4. Therefore, distance can be used effectively as a "shield" from radiation. Thus, even small increases in distance can greatly reduce the radiation exposure.

As an example, if the radioactive waste container in the lab is kept one foot away from the work station, how much is the exposure reduced if the waste container is moved to a corner of lab 6 feet away? Solution: the distance is increased from 1 to 6 feet, this is a factor of 6 times. The inverse square law says that the intensity will decrease by the square of this, which is $6^2 = 36$. By moving the waste container to the corner of the lab, the exposure to persons at the work station has been decreased by 1/36.

The inverse square law dictates the use of increased distance between the user and the radiation source. This can be accomplished with tongs, tweezers, pipettes, or pliers. Also, it is prudent to place your radioactive waste as far away as possible to make use of the inverse square law.

Biological Effects

Radiation effects on humans can be considered as either somatic (effects which manifest themselves in the exposed individual) or genetic.

The somatic category includes acute and delayed effects. Acute effects manifest themselves within days to weeks after exposure. Delayed effects may not show up for years after exposure. Acute radiation syndrome refers to short-term, whole-body dose. A high dose causes damage to many vital tissue and organs simultaneously. The results on the human body depend greatly on the details of the exposure and the individual. Acute radiation syndrome is characterized by four sequential stages. The initial, or prodromal, stage lasts for the first 48 hours post-exposure. The individual is likely to exhibit a feeling of tiredness, nausea, loss of appetite (anorexia), and sweating. The remission of these symptoms marks the beginning of the second, or latent, stage. The latent stage can last from 48 hours to 2-3 weeks after the exposure. The individual will generally exhibit signs of well-being. The third, manifest illness, stage lasts from about 6-8 weeks post-exposure. Symptoms include fever, loss of hair (epilation), lethargy, and perception difficulties. Hemorrhaging and infection will result from damage to the hematologic system. If doses were high enough, gastrointestinal distress (e.g. vomiting) will also be present. Provided the individual survives the third stage, the fourth stage is recovery. This stage may take weeks to months.

An acute, whole-body dose of 450-500 rad of gamma-rays would be lethal to about 50% of the human exposed population, assuming no medical care is administered. In general, this dose is termed the LD_{50}, i.e. the lethal dose for 50% of an exposed population. The term $LD_{50/30}$, refers to the lethal dose to kill 50% of a population in 30 days.

Latent somatic effects show up many years post-irradiation. Leukemia and other cancers are examples of late somatic effects.

Genetic effects are not observed until the next generation. These genetic mutations are seldom the gross disfiguring types portrayed in horror movies. In fact, the vast majority of genetically transmitted mutations result in no observable changes.

Doses of radiation received by workers in NMSU laboratories are chronic doses and often are indistinguishable from background. Acute doses are not possible when working with the μCi and mCi amounts of radioactivity in research laboratories. For specific information, "Radionuclide Safety Information Sheets" for the commonly used radionuclides are found in Appendix G.

Somatic and Genetic Effects

Radiation effects on humans can be considered as either somatic (effects which manifest themselves in the exposed individual) or genetic.

The somatic category includes acute and delayed effects. Acute effects manifest themselves within days to weeks after exposure. Delayed effects may not show up for years after exposure. Acute radiation syndrome refers to short-term, whole-body dose. A high dose causes damage to many vital tissue and organs simultaneously. The results on the human body depend greatly on the details of the exposure and the individual. Acute radiation syndrome is characterized by four sequential stages. The initial, or prodromal, stage lasts for the first 48 hours post-exposure. The individual is likely to exhibit a feeling of tiredness, nausea, loss of appetite (anorexia), and sweating. The remission of these symptoms marks the beginning of the second, or latent, stage. The latent stage can last from 48 hours to 2-3 weeks after the exposure. The individual will generally exhibit signs of well-being. The third, manifest illness, stage lasts from about 6-8 weeks post-exposure. Symptoms include fever, loss of hair (epilation), lethargy, and perception difficulties. Hemorrhaging and infection will result from damage to the hematologic system. If doses were high enough, gastrointestinal distress (e.g. vomiting) will also be present. Provided the individual survives the third stage, the fourth stage is recovery. This stage may take weeks to months.

An acute, whole-body dose of 450-500 rad of gamma-rays would be lethal to about 50% of the human exposed population, assuming no medical care is administered. In general, this dose is termed the LD_{50}, i.e. the lethal dose for 50% of an exposed population. The term $LD_{50/30}$, refers to the lethal dose to kill 50% of a population in 30 days.

Latent somatic effects show up many years post-irradiation. Leukemia and other cancers are examples of late somatic effects.

Genetic effects are not observed until the next generation. The vast majority of genetically transmitted mutations result in no observable changes.

Dose-Effect Models for Response

At least three different dose-effect models are widely presented, although human data fails to suggest any specific dose-response model is best. The threshold model, the linear response model, and the linear-quadratic response model all have various aspects they describe better than the others. The Figure below illustrates three different radiation doses versus biological effect curves.

Linear Response Model

This model assumes that every increase in radiation exposure increases the risk of detrimental effects. This is the model assumed in radiation protection. Therefore, a small dose of radiation is assumed to result in a small increased chance of developing a fatal cancer or genetic mutation. This model results in the most conservative dose limits.

Linear Quadratic Response Model

This model is described by a quadratic function initially (x^2) and then turns more linear at higher doses. Most radiation-induced solid cancers may be predicted by a linear quadratic function, but insufficient low-dose data exists to support this model.

Threshold Response Model

This model is based on a threshold value for the dose-injury response, such that below a certain value there is no risk. Above this threshold the risk linearly increases with dose. This dose effect model represents the observed relationship. At this time, no experimental study has shown an increased risk for cancer in adults below approximately 15 rem (acute, whole-body dose). Conversely, no evidence exists to conclusively support this model.

As Low As Reasonably Achievable

Radiation protection guidelines are based on the assumption that there is no threshold for radiation exposure risk (e.g. linear response model). This is a conservative assumption intended to protect personnel. Radiation guidelines also assume that the risk of injury linearly increases with dose. A further conservative simplification used in radiation protection is the lack of distinction between acute and chronic exposures. This means that dose limits are treated as if they are received as acute doses and do not include effects mitigated by cell repair. If a dose is fractionated over several weeks, the cells have time to repair and recover. Dose fractionation has a reduced biological effect compared to acute irradiation. Radiation protection standards assume all doses are acute.

Another important principle used in radiation protection is the ALARA principle. This stands for "As Low As Reasonably Achievable', which means that exposures should be as low as possible when considering economic and social factors. The ALARA concept strives to keep personnel doses low, yet still maintain an effective and productive working environment. This philosophy dictates sensibility when using radioactive material. Personnel should strive to reduce unnecessary exposures.

Radiation Exposure Risks

Exposure may be received from radioactive materials which are external to the body (external exposure) or from radioactive materials which are inside the body (internal exposure) or both. Since any radiation dose is assumed to increase the risk of health effects in the exposed individual, all radiation doses should be minimized to the extent that is practical. Furthermore, no exposure is warranted unless there is an expectation that the activity will yield a benefit which exceeds the risk.

While NMSU has a responsibility as an employer to provide a safe work environment, the primary responsibility for keeping an individual's radiation dose as low as reasonably achievable (ALARA) rests with that individual. The following guidelines will enable you to keep your radiation dose ALARA.

Minimizing External Exposures

Time

Decreasing exposure time decreases the radiation dose proportionately. It is important to use radioactive materials efficiently. To this end, "dry-runs" of critical steps in a new protocol using a non-radioactive substitute can help identify problems, avoid errors, and speed the completion of the task. Radioactive materials which are capable of generating external dose rates should not be left unshielded any longer than is necessary.

Dose = Dose Rate x Exposure Time

Distance

Increasing the distance from a source of radiation is frequently the most effective and economical means to reduce the radiation dose. The radiation dose rate varies with the inverse square of the distance from the source, in most cases. For this reason, remote handling devices such as tongs, tweezers or other long- handled tools should be used when handling significant quantities of radioactive materials. Stay as far away as practical from the source of radiation. For a point source (sources with small dimensions), consider:

$I_1 d_{12} = I_2 d_{22}$

where: d_1 and d_2 refer to distances from the point source

I_1 and I_2 refer to the Intensities of the radiation levels at distances d_1 and d_2

Example: A small sealed gamma radiation source reads 75 mR/hr at one inch. What is the radiation level at 2 feet?

From the formula $I_1 d_1^2 = I_2 d_2^2$

d_1 =1 inch d_1^2 = 1 inch ^{2}
d_2 = 2 feet = 24 inches d_2^2 = 576 inches ^{2}
Solve for I^2 I_2
= $I_1 d_{12} / d_{22}$
$I^2 = \frac{(75mR)(1\ inches^2)}{576}$
I^2 = 0.13mR/hr

Shielding

Shielding a source of radiation generally reduces the radiation levels for those working in the vicinity. Shielding is important for sources which are in use or in storage.

- Different materials shield different types of radiation.
  - Beta emitting radionuclides are best shielded by low atomic number absorbers such as Plexiglas. Three-eighths inch of Plexiglas is adequate to shield even the high-energy beta particles emitted by P-32.
  - Gamma emitting radionuclides are best shielded by high atomic number and high-density materials, such as lead, iron, or concrete. Shield thickness will depend upon many factors, such as nuclide, quantity and storage location
  - Neutron emitting radionuclides/sources are best shielded by low atomic number (hydrogenous) materials, such as water, paraffin, plastics, or concrete. Shielding calculations for neutrons can be very difficult
  - Alpha emitting radionuclides are not an external hazard, so do not require shielding. Refer to the following section entitled Control of Internal Exposure

Shielding Effects - Alpha and beta radiation can be completely stopped. However, for gamma and beta, shielding is often measured by what proportion of radiation is stopped. A typical unit is tenth value layer (TVL). For gammas of certain energy, two inches of lead decreases the intensity to one tenth. A second two inches of lead will reduce the intensity to one tenth again or a total of 1/100 for four inches of lead. As a practical matter, gammas and neutrons can be shielded, but in actuality additional shielding only reduces intensity by a given proportion.

Source Reduction and Substitution

External dose rates are directly proportional to the activity of a given radionuclide. By ordering only that quantity of radioactive material needed for the immediate requirements, doses to laboratory personnel will be reduced. Furthermore, accident potential and accident consequences will be minimized.

Where possible, one radionuclide may be substituted for another resulting in lower external doses, for example, using S-35 or P-33 instead of P-32. Nonradioactive agents and methods are often available which can be used instead of radioactive techniques.

Minimizing Internal Exposures

Time, distance, and shielding are obviously not applicable when the radioactive material is already inside the body. Furthermore, the dead layer of skin (and to some degree, the living skin) which protects us from some external sources is not a factor when sources are inside the body. In most cases, removal of radioactive materials from the body cannot be accelerated beyond the body's own natural removal rate. Preventing intake of radioactive materials must, therefore, be the chief means by which internal exposures are controlled.

- The four routes by which radioactive materials can be taken into the body are:
  - Inhalation o Ingestion
  - Absorption through the skin
  - Injection through wounds

- Ventilation Controls - A fume hood which is suitable for use of radioactive materials must be used when using volatile radioactive compounds (those which could reasonably become airborne). Examples of volatile radioactive compounds include I-125 or I-131 as NaI solution, tritiated water (HTO) or powdered solids which are radioactive. In addition, nonvolatile compounds which are heated, agitated, powdered, or otherwise treated in the lab in a manner which could cause them to become airborne shall be performed in a fume hood. o Fume hoods used for radioactive material work must be inspected and flow checked at least quarterly
  - No AU may use more than 10 mCi of radioactive iodine (e.g., I- 125 or I-131) at any one time in any fume hood without having either charcoal filtration on the hood exhaust or RSC approval.

Procedural Controls for Minimizing Exposure

- Smoking, eating or drinking in areas where radioactive material is used or stored is not allowed.
- No food or drinks in refrigerators / freezers where radioactive materials are stored.
- Microwave ovens in laboratories where radioactive materials are used or stored cannot be used to heat food.
- Ice from ice machines located in a radioactive material laboratory cannot be used for personal consumption.
- Wear safety glasses, gloves, lab coat, long pants (or equivalent) and closed-toe shoes when working with unsealed radioactive materials.
- Do not pipette by mouth.
- Use a spill tray lined with absorbent paper when working with radioactive liquids.
- Use secondary containment when transferring unencapsulated radioactive materials from one room to another.
- Wash hands after working with radioactive materials.
- Survey personnel and work areas frequently.
- Label containers containing radioactive material.

- ❖ Delineate and label radioactive work areas

APPENDIX D ANIMAL CARE PROCEDURES

Personnel Protection

In addition to the general Personal Protection Procedures, the following procedures should also be followed when working with animals and radioactivity.

- ❖ Maintain control of radioisotopes and radioactive animals against unauthorized access by personnel.

- ❖ Use protective apparel as designated appropriate for the laboratory involved to protect the person against radioactive contamination, animal bites and scratches.

- ❖ Maintain adequate ventilation in the animal laboratory to minimize personnel exposure to airborne concentrations of radioactive materials. Utilize fume hoods as necessary for radioisotopes and sample preparation, contamination food preparations, and the injection of radioisotopes into animals.

Laboratory Management

- ❖ Follow good radiological safety techniques for handling and packaging sacrificed animals, handling and cleaning cages, and the collection of solid and liquid waste from contaminated animals and cages for proper disposal.

- ❖ Contaminated cages and laboratory equipment shall not be removed from the laboratory unless authorized, properly labeled and packaged to prevent a spread of radioactive contamination.

- ❖ Each cage that houses a "hot" animal or has housed a "hot" animal shall bear an appropriate radiation label unless the cage has been throughly cleaned and is found essentially free of radioactive contamination.

- ❖ Place radioactive waste (urine, feces, bedding, cage rinse, blood, tissues) in designated containers and maintain proper storage.

- ❖ Dispose of liquid and solid radioactive waste as authorized by the RSO.

- ❖ Maintain adequate records on radioactive animals so that animal carcasses and other waste can be properly disposed. This should include information on isotope, total quantity/animal, and balance of activity in the carcass or distributed in the excreta.

Animal Care

- Keep animals that are contaminated with radioactivity in designated areas.

- Follow procedures and/or instructions concerning the care of animals, collection of samples and the cleaning of animal housing. Individual users shall provide additional procedures and specify precautions as may be necessary.
- Radioactive animal feed shall be maintained in property labeled and closed containers in designated areas.

- Animals and parts of animals which contain radioisotopes may be transported to other radioisotope laboratories only as authorized and as delineated by approved procedures.

Recommended Procedure for Cleaning Radioactively Contaminated Cages

- Wear adequate protective clothing.

- Use as little water and as few sponges as possible to accomplish optimal cleaning.

- Place contaminated cleaning material and contaminated waste in containers as instructed.

- After the cages have been cleaned to remove the majority of the contamination, they may be scrubbed with a brush or sponge and cleaning solution in the sink.

- Allow the cleaned cages to air dry and survey them for contamination. Re-clean as necessary.

- Cages that are slightly contaminated may be scrubbed in the sink without first having to clean them as above.

- Utilize disposable cage bottoms and disposable cages for highly radioactive operations when practical.

- Follow any special instructions provided by the cage manufacturer.

APPENDIX E LICENSE SEALED SOURCE CONDITIONS

Leak testing of sealed sources shall be conducted in accordance with the conditions listed in the NMSU Radioactive Materials License issued by the State of New Mexico Radiation Control Bureau. The specific license conditions pertaining to sealed sources are listed below:

1. Each sealed source containing radioactive material, other than Hydrogen 3, with a half-life greater than thirty days and in any form other than gas shall be tested for contamination and/or leakage prior to use and at six month intervals thereafter.

2. Not withstanding the periodic leak test required above, any licensed sealed source is exempt from such leak tests when the source contains 100 microcuries or less of beta and/or gamma emitting material or 10 microcuries or less of alpha emitting material.

3. Each sealed source that is designed to emit alpha particles is tested for leakage or contamination at intervals not to exceed 3 months, or at alternative intervals specified by the source manufacturer and as approved by the department, NRC or an agreement state.

   Note: Portable nuclear gauges with Am-241: Be sources and the Pu-239: Be irradiator are neutron, not alpha sources and this condition does not apply.

4. Troxler Model 3411B portable nuclear gauges shall be tested at intervals not to exceed 1 year, (annually).

5. Except for alpha sources, the periodic leak test required by this condition does not apply to sealed sources that are stored and not being used. The sources excepted from this test shall be tested for leakage prior to any use or transfer to another person unless they have been leak tested within six months prior to the date of use or transfer.

6. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. The test sample shall be taken from the sealed source or from the surfaces of the device in storage on which one might expect contamination to accumulate. Records of leak test results shall be kept in units of microcuries.

7. If the test reveals the presence of 0.005 microcurie or more of removable contamination, the licensee shall immediately withdraw the seated source from use and shall cause it to be decontaminated and repaired or to be disposed of in accordance with regulations. A report shall be filed within five days of the test with the New Mexico Environment Department, Radiation Protection Program, P.O. Box 26110, 1190 Saint Francis Dr., Santa Fe, NM 87502-6110, describing the equipment involved, the test results, and the corrective action taken.

8. The licensee is authorized to collect samples for leakage and/or contamination analyses by the manufacturer or by persons specifically licensed by NMED to perform such services.

9. Sealed sources shall not be opened or removed from their respective source holders by the licensee.

APPENDIX F LICENSE UNIT CONVERSIONS

TO CONVERT	INTO	MULTIPLY BY
atomic mass units	grams	1.66×10^{-24}
atomic mass units	mev	931.478
Barns	sq cm	10^{-24}
Becquerels	curies	2.7027×10^{-11}
Becquerels	piocuries	27.027
Calories	ergs	4.184×10^{7}
Calories	joules	4.184
Curies	becquerels	3.7×10^{10}
curies	dis/sec	3.7×10^{10}
curies	dis/min	2.22×10^{12}
curies	dpm	2.22×10^{12}
curies	millicuries	1000
curies	microcuries	1,000,000
curies	picocuries	10^{12}
curies	kilocuries	10^{-3}
dis/min	millicuries	4.505×10^{-10}
dis/min	microcuries	4.505×10^{-7}
dis/sec	millicuries	2.703×10^{-8}
dis/sec	microcuries	2.703×10^{-5}
Ergs	joules	10^{-7}

Gallons	pints (liq)	8
gallons (US H_2O 60 □ F))	lbs of H_2O	8.3282
gallons (US liq)	liters	3.785
gram-calories	joules	4.186
Grams	joules/cm	9.807×10^{-5}
Grams	joules/meter (newtons)	9.807×10^{-3}
Grams	kilograms	0.001
Grams	miligrams	1000
Grays	rads	100
Hours	days	0.04167
Hours	weeks	5.952×10^{-3}
Inches	centimeters	2.54
Inches	meters	0.0254
Inches	milimeters	25.4
Kilocuries	curies	103
Kilograms	grams	1000
Kilograms	joules/cm	0.09807
Kilograms	joules/meter (newtons)	9.807
Kilograms	pounds (avdp)	2.205
kilograms/cu meter	grams/cu cm	0.001

TO CONVERT	**INTO**	**MULTIPLY BY**
Liters	gallons (US liq)	0.2642
Liters	pints (US liq)	2.113
Liters	quarts (US liq)	1.057
liters	cu cm	1000
Mev	ergs	1.6×10^{-6}
Microcuries	dis/sec	3.700×10^{4}
Microcuries	picocuries	1×10^{6}
Microcuries	dis/min	2.220×10^{6}

Millicuries	dis/sec	3.700×10^{7}
Millicuries	dis/min	2.220×10^{9}
Milligrams	grams	0.001
milligrams/liter	parts/million (ppm)	1
Milliliters	liters	0.001
Millimeters	centimeters	0.1
Rads	J/kg	0.01
Rads	MeV/g	6.242×10^{7}
Rads	grays	2-Oct
rads	ergs/g	100
rads	MeV/cm^3 of air (stp)	8.071×10^{4}
Rems	sieverts	10-2
Roentgen	esu/cu cm (air)	1
Roentgen	ion prs/cu cm (air)	2.083×10^{9}
Roentgen	ion prs/gm (air)	1.61×10^{12}
Roentgen	mev/cu cm (air)	6.77×10^{4}
Roentgen	mev/gm (air)	5.24×10^{7}
Roentgen	ergs/gm (air)	83.8
Roentgen	cals/gm (air)	2.0×10^{-6}
Sievert	rems	100

APPENDIX G RADIONUCLIDE SAFETY DATA SHEETS

^{14}C	Nuclide Safety Data Sheet Carbon-14 www.nchps.org	^{14}C

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Max.: 156 keV; Average: 49 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	5730 years
	Biological $T_{½}$:	12 days
	Effective $T_{½}$:	Bound - 12 days; unbound - 40 days
Specific Activity:	4.46 Ci/g [0.165 TBq/g] max.	
Beta Range:	Air:	24 cm [10 inches]
	Water/Tissue:	0.28 mm [0.012 inches]
	[~1% of ^{14}C betas transmitted through dead skin layer, i.e. 0.007 cm depth]	
	Plastic:	0.25 mm [0.010 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[1]:	6.36E-12 Sv/Bq [0.023 mrem/uCi] of $^{14}CO_2$ inhaled; 5.64E-10 Sv/Bq [2.09 mrem/uCi] organic compounds inhaled/ingested
Critical Organ:	Fat tissue [most labeled compounds]; bone [some labeled carbonates]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure - None from weak ^{14}C beta Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for ^{14}C, no intake = no dose]
Provide a urine sample to Radiation Safety whenever your monthly ^{14}C use exceeds 5 mCi, or after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM, ~10% efficiency];
Beta Scintillator [e.g. Ludlum 44-21, ~5% efficiency]

Wipe Test: Liquid Scintillation Counting is the best readily available method for counting ^{14}C wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many ^{14}C compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.

[1] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab that staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{3}H	Nuclide Safety Data Sheet Hydrogen-3 [Tritium] www.nchps.org	^{3}H

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Max.: 18.6 keV; Average: 5.7 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	12.3 years
	Biological $T_{½}$:	10 - 12 days
	Effective $T_{½}$:	10 - 12 days*

* Large liquid intake (3-4 liters/day) reduces effective $T_{½}$ by a factor of 2+; ^{3}H is easily flushed from the body

Specific Activity:	9650 Ci/g [357 TBq/g] max.	
Beta Range:	Air:	6 mm [0.6 cm; 0.25 inches]
	Water:	0.006 mm [0.0006 cm; 3/10,000 inches]
	Solids/Tissue:	insignificant [No ^{3}H betas pass through the dead layer of skin]

II. RADIOLOGICAL DATA

Radiotoxicity[1]: Least radiotoxic of all nuclides; CEDE, ingestion or inhalation:
- Tritiated water: 1.73E-11 Sv/Bq (0.064 mrem/uCi) of ^{3}H intake
- Organic Compounds: 4.2E-11 Sv/Bq (0.16 mrem/uCi) of ^{3}H intake

Critical Organ: Body water or tissue
Exposure Routes: ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard: External Exposure - None from weak ^{3}H beta
Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the only readily available method to assess intake [for tritium, no intake = no dose]
Be sure to provide a urine sample to Radiation Safety whenever your monthly ^{3}H use exceeds 100 mCi, or after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Liquid Scintillation Counting is the only readily available method for detecting ^{3}H
NOTE: PORTABLE SURVEY METERS WILL NOT DETECT LABORATORY QUANTITIES OF ^{3}H

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many tritium compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.
- While tritiated DNA precursors are considered more toxic that ^3H_2O, they are generally less volatile and hence do not normally present a greater hazard
- The inability of direct-reading instruments to detect tritium and the slight permeability of most material to [tritiated] water & hydrogen [tritium] facilitates undetected spread of contamination. Use extreme care in handling and storage [e.g. sealed double or multiple containment] to avoid contamination, especially with high specific activity compounds.

---

[1] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156; Radionuclide and Radiation Protection Data Handbook [Delacroix, et al; Radiation Protection Dosimetry, Kent, England: Nuclear Technology Publishing 1998], p. 19.

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{32}P	Nuclide Safety Data Sheet Phosphorous-32 **www.nchps.org**	^{32}P

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 1,710 keV; Average: 695 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	14.29 days
	Biological $T_{½}$:	Bone ~ 1155 days; Whole Body ~ 257 days[1]
	Effective $T_{½}$:	14.29 days
Specific Activity:	286,500 Ci/g [10,600 TBq/g] max.	
Beta Range:	Air:	610 cm [240 inches; 20 feet]
	Water/Tissue:	0.76 cm [0.33 inches]
	Plastic:	0.61 mm [3/8 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[2]: Inhaled: 2.6E-8 Sv/Bq [95 mrem/uCi] Lung; 4.2E-9 Sv/Bq [16 mrem/uCi] CEDE
Ingested: 8.1E-9 Sv/Bq [30 mrem/uCi] Marrow; 2.4E-9 Sv/Bq [8.8 mrem/uCi] CEDE

Critical Organ: Bone [soluble ^{32}P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]

Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption

Radiological Hazard: External Exposure [unshielded dose rate at 1 mCi ^{32}P vial mouth[3]: approx. 26 rem/hr], Internal Exposure & Contamination

III. SHIELDING

Shield ^{32}P with 3/8 inch Plexiglas and monitor for Bremstrahlung; If Bremstrahlung X-rays detected outside Plexiglas, apply 1/8 to 1/4 inch lead [Pb] shielding outside Plexiglas

The accessible dose rate should be backgound but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{32}P

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM];
Beta Scintillator [e.g. Ludlum 44-21]

Wipe Test: Liquid Scintillation Counting is an acceptable method for counting ^{32}P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake].
- Store ^{32}P (including waste) behind Plexiglas shielding [3/8 inch thick]; survey (with GM meter) to check adequacy of shielding (accessible dose rate < 2 mR/hr; should be backgound); apply lead [Pb] shielding outside Plexiglas if needed.
- Use 3/8 inch Plexiglas shielding to minimize exposure while handling ^{32}P.
- Use tools [e.g. Beta Blocks] to handle ^{32}P sources and contaminated objects; avoid direct hand contact.
- Always have a portable survey meter present and turned on when handling ^{32}P.
- ^{32}P is not volatile, even when heated, and can be ignored as an airborne contaminant[4] unless aerosolized.
- White vinegar can be an effective decontamination solvent for this nuclide in most forms.

[1] NCRP Report No. 65, p.88
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156
[3] Dupont/NEN, Phosphorous-32 Handling Precautions [Boston, MA; NEN Products, 1985]
[4] Bevelacqua, J. Contemporary Health Physics [New York; John Wiley & Sons, 1995], p. 282

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff are not permitted to pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{33}P	Nuclide Safety Data Sheet Phosphorous-33 **www.nchps.org**	^{33}P

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 248.5 keV; Average: 76.4 keV	
Half-Life [T½] :	Physical T½:	25.3 days
	Biological T½:	Bone ~ 1155 days; Whole Body ~ 257 days[1]
	Effective T½:	25.3 days
Specific Activity:	156,000 Ci/g [5,780 TBq/g] max.	
Beta Range:	Air:	50 cm [~ 20 inches]
	Water/Tissue:	0.06 cm [0.024 inches]
	Plastic:	0.05 cm [0.02 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[2]:	15.6 mrem/uCi [Lung] & 2.32 mrem/uCi [CEDE] of ^{33}P inhaled 1.85 mrem/uCi [Bone Marrow] & 0.92 mrem/uCi [CEDE] of ^{33}P ingested
Critical Organ:	Bone [soluble ^{33}P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure - mCi quantities not considered an external hazard Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for ^{33}P, no intake = no dose].
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected.
No dosimetry badges needed when working with ^{33}P [beta energy too low to be detected]

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM]
Beta Scintillator [e.g. Ludlum 44-21]

Wipe Test: Liquid Scintillation Counting works well for counting ^{33}P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- ^{33}P is not volatile, even when heated, and can be ignored as an airborne contaminant[3] unless aerosolized.
- White wine vinegar can be an effective decontamination solvent for this nuclide in most common chemical forms.

[1] NCRP Report No. 65, p.88
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156
[3] Bevelacqua, J. Contemporary Health Physics [New York; John Wiley & Sons, 1995], p. 282

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{125}I	Nuclide Safety Data Sheet Iodine-125 **www.nchps.org**	^{125}I

I. PHYSICAL DATA

Radiation:	Gamma - 35.5 keV (7% abundance)	
	X-ray - 27 keV (113% abundance)	
Gamma Constant:	0.27 mR/hr per mCi @ 1.0 meter [7.432E-5 mSv/hr per MBq @ 1.0 meter][1]	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	60.14 days
	Biological $T_{½}$:	120-138 days (unbound iodine)
	Effective $T_{½}$:	42 days (unbound iodine)
Specific Activity:	1.73E4 Ci/g [642 TBq/g] max.	

II. RADIOLOGICAL DATA

Radiotoxicity[2]:	3.44E-7 Sv/Bq (1273 mrem/µCi) of ^{125}I ingested [Thyroid]
	2.16 E-7 Sv/Bq (799 mrem/µCi) of ^{125}I inhaled [Thyroid]
Critical Organ:	Thyroid Gland
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb]	0.02 mm (0.0008 inches)	0.07 mm (0.003 inches)

→ The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{125}I
- Conduct a baseline thyroid scan prior to first use of radioactive iodine
- Conduct thyroid scan no earlier than 6 hours but within 72 hours of handling 1 mCi or more of ^{125}I or after any suspected intake

V. DETECTION & MEASUREMENT

Portable Survey Meters:

Geiger-Mueller [e.g. Bicron PGM,] to assess shielding effectiveness

Low Energy Gamma Detector [e.g. Ludlum 44-21, ~19% eff. for ^{125}I] for contamination surveys

Wipe Test: Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Use shielding [lead or leaded Plexiglas] to minimize exposure while handling mCi quantities of ^{125}I
- Avoid making low pH [acidic] solutions containing ^{125}I to avoid volatilization
- For Iodinations:
  - Use a cannula adapter needle to vent stock vials of ^{125}I used; this prevents puff releases
  - Cover test tubes used to count or separate fractions from iodinations with parafilm or other tight caps to prevent release while counting or moving outside the fume hood.

[1] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998], p. 6-11
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 136, 166

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

APPENDIX H PORTABLE NUCLEAR GAUGE PROTOCOLS

NMSU Safety Protocol: ^{241}AM (BE) Neutron Probe

The use of ^{241}Am (Be) neutron probes (gauges) is contingent upon prior approval by the NMSU Radiation Safety Committee (RSC). To obtain RSC approval

- ❖ Submit an Authorization for Radioactive Material Use request for review by the NMSU RSC. Contact the NMSU Radiation Safety Officer (RSO) for specific instructions.
- ❖ Agree to use this safety protocol or submit an alternative and equivalent procedure that you develop to meet your unique needs.
- ❖ Download the complete protocol on the EHS&RM Web Site

NRC Nuclear Gauge Safety Guide

NREG /BR -0133, Working Safely With Nuclear Gauges, Rev 2, February 1996