RADIATION SAFETY MANUAL

UNIVERSITY OF
ARKANSAS

IN CASE OF EMERGENCY, CALL:
Radiation Safety Officer (479) 263-2572
University Police (479) 575-2222
(see Section XI of this manual for additional instructions)
October 10, 2019

REVISION CONTROL SHEET

REVISION #	DATE	INITIALS	DESCRIPTION OF CHANGE
0	**October/19**	**PC**	Manual commensurate with the RAM broad-scope License issued on June 3, 2019

FOREWORD

RADIATION SAFETY is the responsibility of all faculty, staff and students who are directly or indirectly involved in the use of radionuclides or radiation-producing machines.

The Radiation Safety Committee is responsible for the University's radiation control program outlined in this manual.

The State of Arkansas has also issued Registrations for the use of radiation producing machines (such as x-ray devices) at the University. While the broad radioactive materials license does not cover the use of these devices, they are included in this manual for radiation safety completeness and uniformity in radiation protection practices at the University.

The use of radiation in a university, where a large number of people may be unaware of their exposure to radiation hazards, makes strict adherence to procedures established by state and federal authorities of paramount importance for the protection of the University, the safety of its faculty, staff, and students, and the protection of the environment.

It is the responsibility of all faculty members, staff, and students involved in radiation work to become thoroughly familiar with the University's radiation safety program and to comply with its requirements and all applicable federal and state laws and regulations. Radiation safety depends on a continuous awareness of potential hazards and on the acceptance of no short cuts in order to keep radiation exposures and releases of radionuclides to the environment as low as reasonably achievable (ALARA).

NOTICE

The purpose of this Manual is to supplement federal, state and local regulations for the control of radiation and in no case is it intended to replace these regulations.

In any event where existing or future federal, state, or local regulations are found to differ from the requirements contained in this Manual, those legally accepted regulations shall be followed.

On July 1, 1963, the U. S. Atomic Energy Commission (now the U. S. Nuclear Regulatory Commission), through an agreement with the State of Arkansas relinquished its regulatory authority over radioactive materials (except certain quantities of special nuclear materials) to the State of Arkansas. As an "Agreement State", the State of Arkansas exercises the authority to license and regulate the possession, use, and disposal of radioactive materials within the state. Organizationally that authority is administered by the Arkansas Department of Health.

This Manual would be submitted for approval by the Arkansas Department of Health and would replace the "RADIATION SAFETY MANUAL" dated August 2010. This revised Manual is dated October 10, 2019.

Appendix I of this Manual provides definitions of words and phrases used in this manual. They are provided for a common understanding of terminology. Except as noted in Appendix I, these definitions are identical to those found in the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation.*

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For the

University of Arkansas

I. ADMINISTRATION

A. RADIATION SAFETY COMMITTEE COMPOSITION

The Radiation Safety Committee of the University of Arkansas shall be composed of a Chair, a Vice-Chair, and at least five additional members. The Committee, the Chair and the Vice-Chair shall be appointed by the Provost of the University. Both Chair and the Vice-Chair shall be tenured faculty members.

The Committee shall include, at a minimum, a representative of the University with authority to commit University resources, a representative from the Dale Bumpers College of Agriculture, Food, and Life Sciences, a representative from the College of Engineering, a representative from the J. William Fulbright College of Arts and Sciences, a representative from the University Health Center, a graduate student, the Manager of Environmental Health and Safety, and such other members as the Provost shall deem appropriate. The Vice Chancellor for Research and Innovation, the Director of Research Compliance, the Radiation Safety Officer (RSO) and the Assistant Radiation Safety Officer (ARSO) shall be ex-officio, non-voting members of the Committee.

All Committee Members shall be knowledgeable of and experienced in the safe use of radionuclides.

A.1 Quorum

A majority of the voting members shall constitute a quorum, except a quorum may not be declared without the presence of the Chair or Vice-Chair and the RSO unless one or more of these positions is vacant.

A.2 Meeting Frequency

The Committee shall meet a minimum of four times each calendar year on a called basis. Meetings shall be held in each calendar quarter of the year. The Committee may meet at other times on request of the Chair, Vice-Chair, or the RSO.

B. COMMITTEE CHARTER

B.1 Charge

The Committee shall establish policies to ensure:

1. That licensed radionuclides are used safely. This includes review as necessary of training programs, equipment, facilities, supplies, and procedures;

2. That licensed radionuclides are used in compliance with Arkansas State Board of Health *Rules and Regulations for Control of Sources of Ionizing Radiation* and the Radioactive Material License (the License) issued to the University of Arkansas by the Arkansas Department of Health;

3. That the use of radionuclides is consistent with the philosophy of ALARA as defined in Appendix I;

4. That a program is established to control individual occupational radiation exposures; and

5. That the program shortcomings are identified, and corrective measures are implemented.

B.2 Responsibilities

The Committee shall:

1. Retain expertise to be familiar with all pertinent regulations, the License, and amendments to the License;

2. Review the training and experience of proposed Authorized Users and the RSO to determine qualifications are in accordance with regulatory and License requirements;

3. Review on the basis of safety all Applications to Use Radionuclides and/or Ionizing Radiation Producing Equipment within the University;

4. Prescribe any special conditions for authorizing uses of radionuclides and/or ionizing radiation producing equipment;

5. Review the RSO's report on exposures of all personnel, and, when necessary, require modifications to the operations of the Radiation Protection Program to decrease the levels of exposure;

6. Review the RSO's annual summary report of the Radiation Safety Program and conduct an annual review of the Radiation Safety Program. Following the review, the RSC shall transmit its findings and recommendations to the Provost for University action;

7. Recommend and cause to be implemented any remedial actions to correct deficiencies identified in the Radiation Safety Program;

8. Maintain written minutes of all Committee meetings, including members present, members absent, agenda items, discussions, actions, recommendations, decisions, and numerical results of all votes; and

9. Establish policies so that the University's Radiation Safety Manual and License are amended as required by Arkansas laws and regulations and approve any changes to the Manual;

10. Review and approve all changes to University procedures related to the Radiation Safety Program prior to their implementation and the procedures satisfy regulatory requirements, do not change existing license conditions, and do not decrease the effectiveness of the Radiation Safety Program.

C. MEMBERS

A roster of members of the Radiation Safety Committee shall be maintained by the RSO. The RSO will inform the Arkansas Department of Health of changes in the membership of the Committee

D. RADIATION SAFETY OFFICER

The RSO is charged with implementing the University's Radiation Safety Program and directing the staff of the Radiation Safety Section. The incumbent is within the Office of Environmental Health and Safety (EH&S) and reports directly to the Manager of the Office of Environmental Health and Safety. The Manager of EH&S reports through the Director, Facility Operations and Maintenance to the Associate Vice Chancellor for Facilities, who reports to the Vice Chancellor for Finance and Administration (VCFA). The VCFA reports directly to the Chancellor.

The RSO has direct line of authority from the Chancellor to take such actions as needed to safeguard the public health and safety with regard to radionuclides and ionizing radiation producing equipment.

The RSO has the responsibility to manage the Radiation Safety program in a manner that will:

- Ensure that the radionuclides possessed by the University are limited to the types and quantities authorized.

- Ensure that documentation is maintained that demonstrates that doses to University employees, students, and individual members of the public do not exceed the limits specified in the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation* and that an annual review of personnel radiation doses is conducted to ensure that radiation doses are as low as reasonably achievable (ALARA).

- Ensure the security of radionuclides.
- Ensure the proper posting of notices and other required documents.
- Ensure that radionuclides are transported in accordance with applicable state and federal requirements.
- Ensure that information on radiation safety is made available to Authorized Users and other persons.
- Ensure the proper delivery, receipt, and conduct of radiation surveys for all shipments of radionuclides arriving at or leaving from the University.
- Ensure that appropriate personnel monitoring and bioassays (if required) are provided to all users of sources of radiation and that records of radiation doses received are maintained and reviewed.
- Ensure that appropriate actions are initiated in response to events involving high exposures to radiation and/or radionuclides and trends in increasing personnel exposures.
- Ensure that all users of sources of radiation receive proper radiation safety training and periodic refresher training.
- Ensure the proper storage of all radionuclides including those in radioactive waste and radionuclides not in current use.
- Ensure that leak tests on all sealed sources and calibrations of radiation survey and measuring instruments are performed at required intervals and records are maintained.
- Ensure that an inventory and records of receipt, transfer, and disposal of all sources of radiation are maintained and that radionuclides possessed are within the limits authorized by the license.
- Ensure that all activities involving sources or radiation, including the conduct of radiation surveys of areas where they are used, are performed in a safe manner so that the potential for exposure to radiation and radioactive contamination is maintained ALARA.
- Ensure that any unsafe condition or activity that is found to be a threat to public health and safety or property is terminated immediately.
- Ensure that all users of sources of radiation are properly trained.

- Ensure that all incidents, accidents, and personnel exposures to radiation in excess of the limits set by the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation* are investigated and reported, if required, within the required time limits.

- Ensure that all other records required by the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation* are maintained.

- Ensure that each University Authorization is audited at least annually by Radiation Safety and that these audits include independent measurements of radiation levels in areas of usage of sources of radiation.

- Ensure that radioactive contamination is identified and decontaminated to levels appropriate for unrestricted use by supervising decontamination and recovery efforts following any spill or accident.

E. ASSISTANT RADIATION SAFETY OFFICER

The University will appoint an Assistant Radiation Safety Officer (ARSO) to enhance the implementation of the University's Radiation Safety Program. On a day-to-day basis the ARSO will assist the RSO in managing and implementing the University's Radiation Safety Program. In the absence of the RSO, the ARSO will have the same responsibilities and authorities as the RSO.

II. FACILITIES AND EQUIPMENT

A. GENERAL

The University of Arkansas is required to possess licensure and registration for sources of radiation by Arkansas law and regulations. All radionuclides must be authorized and controlled by licensure from the Arkansas Department of Health. Ionizing radiation producing equipment must be registered with the Arkansas Department of Health. The University has developed a Radiation Safety Program to ensure this control. This Manual addresses radionuclides and ionizing radiation producing equipment.

B. RADIONUCLIDES

The use of radionuclides (including very small quantities of fissionable materials called special nuclear materials) is authorized by a Radioactive Materials License issued to the University of Arkansas by the Arkansas Department of Health. This license gives broad authority for the possession and use of any radionuclide with atomic numbers 3 to 83 inclusive in any form subject to limitations on the total activity of each individual radionuclide and a maximum total quantity (activity) of all radionuclides combined for use in research and development and for educational purposes. In addition, the possession and use of certain specific radionuclides in quantities exceeding these limits, tritium (hydrogen

3), and radionuclides with atomic numbers above 83 are authorized as specified on the License.

A copy of the License is available for inspection in the offices of the RSO.

The License authorizes the use of radionuclides at the following locations:

1. University of Arkansas
   Main Campus
   Fayetteville, Arkansas

2. University of Arkansas
   Agricultural Experiment Station
   Highway 112 North
   Fayetteville, Arkansas

3. University of Arkansas
   Arkansas Research and Technology Park
   Fayetteville, Arkansas

4. Temporary job sites throughout Arkansas not under the exclusive jurisdiction of the federal government.

C. IONIZING RADIATION PRODUCING EQUIPMENT

The Arkansas Department of Health regulates all ionizing radiation producing equipment such as diffractometers, x-ray spectrometers, accelerators, diagnostic x-ray machines, and electron microscopes. The equipment (except accelerator) must be registered with the Arkansas Department of Health within 30 days of its installation at the University. The RSO will register the ionizing radiation producing equipment on behalf of the University.

The possession and use of particle accelerators must be authorized by a Particle Accelerator License issued by the Arkansas Department of Health. The RSO will apply for this type of license, when required, on behalf of the University.

In addition to applying for and obtaining a University Authorization, each Authorized User with ionizing radiation producing equipment shall provide the RSO with the serial number of the equipment as soon as it is received so that the RSO can file the application for registration with the Arkansas Department of Health within the 30-day registration period.

Radiation warning signs must be posted near radiation producing equipment. Examples of the signs are: **CAUTION RADIATION—THIS EQUIMENT PRODUCES RADIATION WHEN ENERGIZED** or **CAUTION X-RAY EQUIPMENT**. The RSO will assist the Authorized User in selecting and placing the appropriate warning signs.

Access to ionizing radiation producing equipment shall be limited so that only trained and authorized individuals can activate the equipment to produce ionizing radiation. This may be achieved by the use of locking mechanisms on the control panels or by other means.

Safety devices such as collimators, interlocks, shielded rooms, warning lights and other safety equipment may be required as conditions of the University Authorization.

Personnel who use ionizing radiation producing equipment may be required to use whole body and extremity dosimeters while operating the equipment.

Authorized Users shall notify the RSO prior to disposing of or transferring any ionizing radiation producing equipment.

III. OPERATIONAL PROCEDURES

A. GENERAL

No person shall possess or use radionuclides and/or ionizing radiation producing equipment at the University of Arkansas unless that individual has been granted a University of Arkansas Authorization to possess and use those radionuclides and/or that equipment. An Authorized User is a person who has been issued such a University Authorization. The procedure for obtaining a University Authorization is given in Section IV of this Manual.

Each Authorized User is responsible for the safe use of such radionuclides and/or ionizing radiation producing equipment. The Authorized User shall:

1. Establish a laboratory specific Radiation Safety Program commensurate with the types and quantities of radionuclides or types of ionizing radiation producing equipment authorized by the applicable University Authorization and adhering to the limitations and requirements of that Authorization,

2. Carry out the required administrative and safety procedures,

3. Select those laboratory practices which are applicable to the work,

4. Ensure proper training of employees and assistants,

5. Supervise all operations carried out under the University Authorization,

6. Maintain written records which document the receipt, use, transfer, storage, and disposal of radionuclides, and the radiation surveys and other tests conducted as part of the laboratory specific safety program,

7. Ensure the laboratory or other facility is properly posted with “Caution Radioactive Materials”, “Caution Radiation Area”, and "Notice to Employees" signs, and

8. Immediately notify the RSO if any unexpected situations arise which might affect the safety of personnel, may potentially cause a health hazard or a danger to the community, or violates any condition of the University Authorization or Arkansas laws or regulations.

The Authorized User shall be provided a current copy of the Radioactive Materials License issued to the University. All personnel shall be trained and acquainted with proper radiation safety practices and supervised to see that these practices are observed.

Every effort shall be made to conduct experiments and operations in such a manner as to keep the radiation exposure of all individuals and releases of radionuclides as low as reasonably achievable (**ALARA)**.

The events of September 11, 2001 have led to increased concern over the physical security and protection of radionuclides. These concerns have resulted in the U. S. Nuclear Commission and the Agreement States including Arkansas instituting “increased controls” over the storage and use of radionuclides above certain “quantities of concern”. Appendix II provides a table of these radionuclides and associated activity levels.

Although at the present time, no University Authorization includes radionuclides above these quantities, this information regarding quantities of concern is provided for planning purposes in the event new projects involving these quantities are proposed. Since such usages will involve the implementation of increased controls by the University and amendment of the License, any individual proposing the use of quantities of concern should coordinate with the RSO as soon as the project is identified.

Provisions of the license will need to be addressed during declared emergencies unless there is an immediate threat to life. If campus activities need to cease where licensed materials are involved, those activities should be suspended and the material properly secured during the suspension.

B. RADIONUCLIDES

In order to maintain compliance with the laws and regulations of the State of Arkansas and the Radioactive Materials License issued to the University, and to ensure proper protection for all personnel, the following procedures shall be incorporated into each local Radiation Safety Program by the Authorized User:

1. Signs shall be posted where radionuclides are present,

2. Radionuclides shall be secured at all times. Specifically, all radionuclides shall be stored in a locked cabinet, refrigerator, freezer, or room, and when not in a locked device or room shall be accompanied at all times by trained personnel.

3. Indirect and/or direct reading dosimeters shall be worn by personnel pursuant to Section VII of this Manual, and dosimetry reading records shall be maintained by the RSO.

4. Direct reading dosimeters shall also be worn and recorded the dose read-out on hourly basis when working in high radiation areas (i.e., areas where radiation levels are greater than 100 millirems per hour (1 mSv/hr)). The RSO shall be notified before each entry into a high radiation area.

5. Radiation detection and measuring instruments shall be available and used in all radionuclide use areas. The instruments shall be capable of detecting and measuring the type of radiation in use. All instruments shall be in calibration during use.

6. Radiation survey instruments shall be checked before beginning use to ensure proper operating conditions and calibration.

7. Working areas shall be surveyed after the use of unsealed radionuclides to determine whether contamination is present. These surveys shall be conducted using the methods, instrumentation, and procedures required by the University Authorization. Under no circumstance should inoperable instrumentation or instruments which are out of calibration be used to perform these surveys. Radiation field levels shall be determined using an instrument capable of detecting the radiation in question. Wipe tests shall be analyzed using an instrument capable of detecting the radiation in question. If wipe samples or direct radiation surveys indicate contamination levels exceeding the limits in Appendix VIII, the area shall be cleaned until the contamination is reduced below these levels. The RSO shall be notified when decontamination is required.

8. Minor spills as defined in Section XI of this Manual shall be cleaned up immediately. If a major spill occurs, do not attempt decontamination. Isolate the area and notify the RSO immediately in accordance with Section XI of this Manual.

9. Protective clothing and hands shall be monitored upon completion of laboratory work involving the handling of unsealed radionuclides.

10. Smoking, drinking, or eating shall not be allowed in any room or area where unsealed radionuclides are used.

11. Employees shall wash their hands thoroughly before leaving any area where unsealed radionuclides are being used.

12. Mouth pipetting of liquid radionuclides shall be strictly forbidden.

13. Long-handled tongs, gloves, smocks, shoe covers, respirators and other equipment shall be used when such safety measures are needed. When in doubt as to whether special equipment is necessary, contact the RSO for assistance.

14. Gloves and smocks shall be worn by employees when working with unsealed radionuclides.

15. Sealed sources shall not be handled with bare hands.

16. Controlling access into radionuclide use areas is the responsibility of the Authorized User.

17. Radionuclides producing a radiation dose rate in excess of 2 millirems per hour (0.02 mSv/hr) at a distance of one foot from the source shall be stored within shielding sufficient to reduce the dose rate to less than 2 millirems per hour (0.02 mSv/hr) at a distance of one foot. Radiation dose rates shall not exist in an unrestricted area that could result in a personnel exposure which exceeds 100 millirems (1 mSv) per year or 2 millirems per hour (0.02 mSv/hr). Radiation areas shall be posted with appropriate warning signs.

18. Unsealed radionuclides shall be stored in leak-proof containers.

19. Work involving liquid radionuclides shall be performed on trays lined with absorbent paper and/or on surfaces protected with plastic-backed absorbent paper.

20. Radionuclides shall not be used in or on human beings. Any animals administered radionuclides, or the products of such animals, shall not be used for human consumption.

21. Radionuclides materials shall not be used in field applications where activity is released without prior approval of the Radiation Safety Committee and the RSO.

22. Conventional chemical and high performance/ low flow fume hoods in which radionuclides are used shall be evaluated semi-annually in accordance with University of Arkansas standard operating procedure “Evaluation of Fume Hoods”.

23. Glassware and equipment containing radionuclides shall be properly labeled and controlled for radioactive decay and/or disposal.

24. Trial runs should be made when practicable to determine proper procedures and to evaluate necessary radiation protection practices.

25. Only designated sinks shall be used for washing contaminated glassware or for disposing of radionuclides. Any release of radionuclides to the sanitary sewer must be approved by the RSO prior to release and in accordance with the conditions and limitations in the University Authorization.

26. Only designated storage boxes, freezers and refrigerators shall be used for the storage of radionuclides. **DO NOT** put food or drinks in any storage box, freezer, or refrigerator used to store radionuclides.

27. Radionuclide storage containers shall be labeled with the following information:

    - Radionuclide
    - Activity and date of assay
    - Authorized User
    - Caution-Radioactive Materials (with radiation symbol)

28. If a suspected or known overexposure occurs, notify the RSO immediately. A written report shall be made in each case of overexposure by both the individual involved and the person supervising the use of the radiation. These reports shall explain fully why the individual involved received an excessive exposure to radiation, and that recommend measures to be taken to avoid a recurrence of the incident.

29. Records of radiation exposures of individuals shall be maintained by the RSO. Reports of exposures shall be available to the individual.

30. Safety glasses, optical glasses, or goggles shall be worn when the skin dose from beta-emitting radionuclides may exceed 100 millirems (1 mSv) per week (0.6 millirems per hour or 0.006 mSv/hr).

31. Proposed changes to a University Authorization shall be submitted in writing to the RSO for approval by the Radiation Safety Committee. Amendment of the University Authorization shall be obtained prior to implementing the change.

32. Approval of the RSO shall be obtained prior to the transfer of any radionuclide to another Authorized User, institution, or licensee.

33. Copies of the "*NOTICE TO EMPLOYEES*" sign shall be posted in a sufficient number of places in every laboratory or workplace where individuals are engaged in activities using radionuclides so that they can be seen by individuals entering the laboratory or work area.

34. Each individual using radionuclides will be familiar with the requirements of this Manual and the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation*. Copies of these regulations are available upon request from

the RSO and via the Internet by link from the Radiation Safety page of the University's website.

35. Individuals involved in operations which utilize, at any one time, more than 100 millicuries of tritium in an unsealed form, other than metallic foil, shall have appropriate bioassays performed within one week following a single operation and at weekly intervals for continuing operations.

36. Additions and alterations to these procedures may be made by the Radiation Safety Committee when in the estimation of the Committee such additions and alterations are necessary for the protection of users of radionuclides, the public, or the environment.

37. For activities involving radionuclides and animals, Authorized Users shall comply with the procedure titled, "Procedures for Laboratory Animal Uses," found in Appendix III of this Manual.

C. LABORATORY SURVEYS AND INSPECTIONS

Laboratory surveys for contamination including direct radiation and smears for removable contamination shall ensure that contamination levels do not exceed the contamination limits in Appendix VIII. If contamination is found that exceeds these limits, the RSO shall be notified and the laboratory decontaminated immediately.

C.1 Surveys by Laboratory Personnel

Each laboratory or work area in which radionuclides are used shall perform regular surveys. These surveys are separate and distinct from the surveys (inspections) performed by the RSO and/or the Radiation Safety staff.

C.1.1 Frequency of Surveys

The frequency of the surveys shall be determined by level of isotope usage. If the laboratory receives a shipment of radionuclides in loose (unsealed) form, a survey shall be performed at a minimum the earlier of:

1. On termination of activities the day the shipment of isotopes is opened and used,

2. At the end of the week during which the isotopes were received and/or used, or

3. As specified in the conditions of the University Authorization.

If the laboratory receives radionuclides in sealed form (Sealed Source), a survey shall be performed:

1. At the close of each day's activities if the source is greater than 1 millicurie,

2. At the close of each week's activities if the source is less than one millicurie, or

3. As specified in the conditions of the University Authorization.

C.1.2 Records of Surveys

Records of all surveys shall be recorded in a laboratory logbook. These survey records shall also be attached to the report section under the labs document section in BioRAFT. The records shall be available for review by the RSO and the Radiation Safety staff at any time. Information recorded as part of the survey shall be at a minimum:

1. The date and time of the survey.

2. The person performing the survey.

3. The reason for the survey.

4. Information on the instrument used to perform the survey including the manufacturer, model number, and serial number of the instrument.

5. The results of the survey including units of measurement.

6. The background reading in the laboratory, taken well away from any known radionuclides.

7. The building, room number, and the locations of the measurement.

C.2 Inspections by Radiation Safety Staff

The RSO or the Radiation Safety staff shall conduct periodic inspections of all laboratories and other work areas where radionuclides are used or stored. These inspections shall be sufficient to determine adherence with this Manual, the conditions of the University Authorization, conditions of the License, and the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation*. If an inspection detects an unsafe condition, the RSO shall cause the unsafe condition to be corrected. If the condition cannot be corrected in a reasonable time, the RSO may require the Authorized User to place radionuclides in a safe condition and stop all usage until the situation is corrected.

C.2.1 Frequency of Routine Inspections

Each Authorized User's program including all laboratories and other work area associated with the program shall be inspected at least annually by the RSO or qualified Radiation Safety staff. More frequent inspections may be conducted if deficiencies were noted during a prior inspection, the program involves the use of large amounts of radioactive materials, an inspection is requested by the Authorized User, or any other situation warrants additional inspections.

Laboratories and other work areas shall be inspected during the process of reviewing applications for a University Authorization. Following the issuance of a University Authorization, an inspection will be conducted within one month following the initial receipt of radionuclides by the Authorized User.

In addition to the staff of the Radiation Safety Section, the RSO may use members of the Radiation Safety Committee or qualified outside individuals to perform or assist in the performance of these inspections.

The overall goal of the inspection program is to ensure that laboratories and other work areas are safe environments for teaching and research and ensure compliance with regulatory requirements for the use of radionuclides.

C.2.2 Records of Routine Inspections

The results of all routine inspections shall be documented and maintained for review by the RSO, the Radiation Safety Committee, and the Authorized User. Information recorded as part of an inspection shall include, as a minimum, the following:

1. The date and time of the inspection.
2. The person(s) performing the inspection.
3. any known radionuclides.
4. The building and room number of the inspection.

The current inspection form, "Radiological Safety Audit Form," is shown in Appendix IV of this Manual. This inspection is recorded in the BioRAFT information management system. This form may be revised at the discretion of the RSO.

C.3 Non-routine Inspections

A non-routine inspection may be performed after any of the following events occur:

1. Cleanup of a spill.
2. Laboratory decommissioning.
3. On request.
4. Detection of an unsafe condition.
5. Any accident or incident involving radionuclides.
6. Any allegation or complaint involving the use or storage of radionuclides.

A non-routine inspection may be performed under any other circumstances when its performance is deemed appropriate by the RSO or the Radiation Safety Committee. Information recorded as part of an inspection shall include, as a minimum, the following:

1. The date and time of the inspection.

2. The person(s) performing the inspection.

3. The reason(s) for the inspection.

4. Information on the instrument(s) used to perform the radiation and/or contamination survey(s).
   a. The manufacturer, model number, and serial number of the instrument.
   b. The latest calibration date of the instrument.

5. The background reading in the laboratory or work area, taken well away from any known radionuclides.

6. The building and room number of the inspection.

If swipes are taken as part of the survey, a record of the swipes and their locations shall be attached to the record of the survey.

The current inspection form, "Radioactive Material Laboratory Survey Form" is shown in Appendix V of this Manual. This form may be revised at the discretion of the RSO.

The "Radioactive Material Laboratory Survey Form" or the equivalent may be used to document the results of non-routine inspections.

D. VIOLATIONS OF REGULATIONS

In the event of an alleged violation of the requirements set forth in this Manual, the University Authorization, the License, or the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation*, the person noting the alleged violation shall immediately contact the RSO or a member of the Radiation Safety Committee. The RSO shall conduct a review or investigation of all such allegations. The Radiation Safety Committee may require the Authorized User to meet and discuss the alleged violation with the Committee. Subsequent action taken by the Committee will depend on the seriousness of the violation and the Authorized User's past record. If the alleged violation is found to be minor, the RSO shall clarify the policies for using radionuclides and shall explain the hazards associated with the violation. If the alleged violation is serious, or the alleged violator shows a flagrant disregard for proper operating procedures, the Radiation Safety Committee may modify, suspend, or revoke the University Authorization issued to the user.

IV. RADIONUCLIDE AND IONIZING RADIATION PRODUCING EQUIPMENT ACCOUNTABILITY

A. APPLICATION FOR UNIVERSITY AUTHORIZATION TO USE RADIONUCLIDES AND/OR IONIZING RADIATION PRODUCING EQUIPMENT

Prior to the initial purchase or use of radionuclides (including so-called exempt quantities or exempt sources) and/or ionizing radiation producing equipment and prior to a change in an existing University Authorization, the user shall make Application to Use Radionuclides and/or Ionizing Radiation Producing Equipment and submit it to the RSO. A copy of the application form, Application to Use Radionuclides and /or Ionizing Radiation Producing Equipment, is shown in Appendix VI of this Manual. This form may be revised at the discretion of the RSO. The RSO shall review and make an evaluation of the intended user's plans for radiation safety.

The evaluation will include:

1. What radionuclides and/or equipment are to be used.
2. The physical form of the radionuclides.
3. The total amounts of the radionuclides will be required at any one time.
4. How the equipment and radionuclides are to be used.
5. The duration of the use of equipment and radionuclides.
6. Where the equipment and radionuclides are to be used, including a scale drawing of the laboratory and/or work area.
7. Who will use the equipment and radionuclides (furnish a list of proposed users).
8. Who will be the Authorized User responsible for proper use of the equipment and radionuclides.
9. Training and experience of individual(s).
10. Where the radionuclides are to be stored.
11. What safety measures are needed to ensure that employees, students, and members of the general public are not exposed to excessive radiation.
12. Where and what warning signs will be posted.

13. What emergency procedures will be taken, should an accident occur.

14. The type of personnel monitoring devices to be worn and bioassays will be performed (if appropriate).

15. The radiation survey and/or wipe survey procedures.

16. If animal use is proposed, procedures for handling animals, animal waste and carcasses.

17. Contact information with references to verify previous University Authorizations and/or use at another institution.

The RSO shall evaluate the application and any supporting materials and prepare a written recommendation with regard to the application. The RSO shall submit the application, his recommendations with regard to it, and a copy of the proposed University Authorization to the Radiation Safety Committee for review and approval. If any issue is raised by a Committee member, the issue shall be resolved prior to issuance of the University Authorization.

New University Authorizations and amendments to University Authorizations shall be approved by a quorum of the Committee with the exception discussed below.

Radiation Safety Committee members may approve University Authorizations and amendments of University Authorizations at a meeting of the Committee or in writing or by electronic means, such as e-mail. Upon completion of the required radiation safety training by the applicant and the Committee's approval, the Authorization will be finalized with the signature of the RSO, and the Committee Chair or Vice-Chair.

The RSO shall maintain a file of each application for and each amendment of a University Authorization, the recommendations of the RSO, Committee member approvals, and the University Authorization as issued. A copy of the latter will be provided to the Authorized User.

If the application proposes to release radionuclide(s) to the sanitary sewer, the application shall clearly state the radionuclide(s) and activities proposed to be released and include procedures for monitoring and quantifying those releases and maintaining records of those releases. The University Authorization will include the limitations on the radionuclide(s) and activities that may be released to the sanitary sewer by the Authorized User

Following the issuance of the Authorization, the RSO or his/her designee shall meet with the new Authorized User (and staff if appropriate) to conduct any final training and hold a question and answer session. The laboratory facilities and/or work areas are again reviewed by the Radiation Safety Section staff; signs are posted; waste containers are provided; and final training is provided.

An Authorized User may submit to the RSO a written request to amend his/her authorization to reduce possession limits, remove places of use, and/or discontinue previously authorized activities. Such requests do not require approval of the Radiation Safety Committee, rather shall be reviewed and processed by the RSO. The amended University Authorization shall be finalized with the signature of the RSO, and the Committee Chair or Vice-Chair.

Visiting researchers may only use radionuclides under the University Authorization and control of a currently Authorized User

B. ORDERING, RECEIVING, AND SHIPPING RADIONUCLIDES

It is the responsibility of each person to comply with the following requirements regarding the purchase of radionuclides at the University. In no event is any employee authorized to purchase, receive or transfer radionuclides until receiving the written approval of the RSO or designated staff member of Radiation Safety. In an emergency, the Chairman of the Radiation Safety Committee may grant an approval.

B.1. Procedure for Ordering and Receiving Radionuclides:

1. Authorized Users may purchase radioactive material by following procedures. The RSO should approve or place all orders for radionuclides and should ensure that the requested radionuclides, quantities, manufacturer, and model are authorized by the License and that the possession limits are not exceeded.

2. During normal working hours, carriers and delivery companies will be instructed to deliver radioactive packages directly to the Radiation Safety Office (or designated receiving area). During off-duty hours, other designated trained personnel may accept delivery of radioactive packages. Any packages containing radionuclides which arrive between 4:30 p.m. and 7:00 a.m. or on Saturdays or Sundays shall be signed for by the RSO or other designated trained individual on duty and taken immediately to the designated receiving area. The person receiving the package should unlock the door, place the package in the designated secured storage area, re-lock the door, and notify the RSO immediately on the next working day.

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3. All purchase requisitions (for regular, standing, or blanket purchase orders) must be approved by the RSO. Purchasing will not accept the order without RSO approval.

4. All radionuclides must be shipped to the attention of the:

Radiation Safety Officer
Environmental Health & Safety
Facilities Management Department
521 South Razorback Road

Fayetteville, Arkansas 72701.

5. The RSO must be notified of and approve all shipments of radionuclides (such as transfers, gifts, samples, or replacements) prior to their receipt.

6. Alternate receiving locations may be considered depending on the half-life of the materials and specific research needs. Requests to receive at an alternate location must be made to the RSO before ordering any materials and approved by the RSC. No matter where a package is received, the receiving procedures must conform to this manual.

7. The use of Fluorine-18 (F-18) with a half-life of 109 minutes by a CHBC laboratory has been approved by RSC to be received at CHEM-313.

B.2 Shipping and Receiving Personnel:

During normal working hours, immediately upon receipt of any package containing radionuclides, the package must be visually inspected for any signs of shipping damage, such as crushed or punctured containers and signs of dampness. Any obvious damage must be reported to the RSO immediately. Do not touch any package suspected of leaking. Request the person delivering the package remain until the person is surveyed by the RSO or a staff member from Radiation Safety.

Outside of normal working hours (e.g., nights, weekends, and holidays), deliveries will be handled by security personnel (or other trained individuals), as described in the above procedures. Since a package containing radionuclides may have detectable external radiation, it they should be taken immediately to the designated storage area. There the RSO or a staff member of Radiation Safety will survey the package for contamination and external radiation levels as soon as practical. A package containing radionuclides should not be allowed to remain in the receiving area any longer than necessary, as it may be a source of radiation exposure to receiving personnel.

Any questions regarding receiving packages containing radionuclides should be referred to the RSO.

The RSO will provide training to shipping and receiving personnel and personnel regarding the handling of packages containing radionuclides.

B.3 Procedure for Safely Opening Packages Containing Radionuclides:

The RSO or staff from Radiation Safety shall open all packages using the following procedures.

1. Wear protective gloves to prevent hand contamination.

2. Visually inspect the package for any sign of damage.

3. Check for Department of Transportation White I, Yellow II, or Yellow III labels, shipping papers, and packing slips for activity of contents to ensure that contents do not exceed the possession limits of the License.

4. Survey the external surfaces of a labeled package to confirm the radiation level shown on the shipping label.

5. Open the outer package (following supplier's directions if provided) and remove packing slip.

6. Open the inner package to verify contents (compare requisition, packing slip and label on the bottle or other container). Check integrity of the final source container (e.g., inspecting for breakage of seals or vials, loss of liquid, discoloration of packaging material, high count rate on smear). Check again that the shipment does not exceed license possession limits.

7. Survey the packing material and packages for contamination before discarding. This should include taking smears of the inner-most container. If contamination is found, treat as radioactive waste. If no contamination is found, obliterate the radiation labels prior to discarding in the regular trash.

8. Maintain records of receipt, package survey, and wipe test results.

The RSO will notify the shipping carrier, the shipper, and the Arkansas Department of Health if radioactive contamination above regulatory limits is found on the package when it was received by the University.

B.4 Radionuclide Transfer Requirements:

Internal Transfers

The transfer of radionuclides from one Authorized User to another must have prior approval from the RSO. All transfers shall be done in a way that minimizes the probability of spillage or breakage. Double containers should be used, including suitable shielding, for such transfers.

External Transfers

Radionuclides shall not be transferred or shipped from the University to persons outside the University without the approval of the RSO. Such transfers/shipments must be packaged and labeled in accordance with applicable U. S. Department of Transportation (DOT), Arkansas Department of Health, or U.S. Postal Service regulations.

Shipments of radionuclides from or by the University shall comply with the requirements of the appropriate regulatory agencies. A file of applicable regulations is maintained by the RSO. A Radioactive Material Shipment Form or equivalent must be completed for each shipment and all shipments shall be approved and prepared by RSO and/or other staff of the Radiation Safety Section possessing the appropriate U. S. Department of Transportation training and certification.

Gifts

On occasion, radionuclides may be offered or donated as gifts by persons from outside the University. All such gifts of radionuclides must be approved by the RSO prior to the physical transfer.

C. INVENTORIES

Each Authorized User shall conduct a physical inventory of all radionuclides held under the University Authorization and submit a signed copy of that inventory to the RSO within one week following the end of each calendar quarter. Failure to conduct and submit an inventory may cause suspension of purchasing radionuclides by the Authorized User and may result in termination of the University Authorization for the user.

V. INSTRUMENTATION

A. GENERAL

Radiation detection and measurement instruments are used to provide information on the type and quantity of radionuclides present. Various types of radiation detection instruments and equipment are used and retained by Radiation Safety. The principal use is for routine monitoring and to provide additional monitoring in the event of a radiation incident or emergency. Radiation Safety maintains records and provides calibration service to Authorized Users for most types of detection and measuring instruments.

B. INSTRUMENTS AND DETECTORS

Although a basic radiation detection/measuring instrument may be provided to an Authorized User by the Radiation Safety, an Authorized User may be required to purchase and use an instrument(s) specific to the laboratory's needs, and must use a detector appropriate for the type of radiation to be detected/measured. Data and Information, including suggested survey instrumentation, for several commonly used radionuclides are included in Appendix VII. For additional information on manufacturers of the types of detection and measuring equipment, contact the RSO.

C. INSTRUMENT CALIBRATION METHODS

Radiation survey instruments at the University shall be calibrated to read within ±20% of the correct exposure reading every twelve (12) months, and after each instrument repair. If the instrument is to be used for direct contamination surveys (fixed), the calibration shall include a determination of the efficiency of the detector (probe) for the radionuclide of interest.

Calibrations are scheduled and provided for by the RSO. At the present time the University uses outside organizations appropriately licensed by the Arkansas Department of Health, another Agreement State, or the U. S. Nuclear Regulatory Commission to perform these calibrations.

Records of all instrument calibrations are maintained by the RSO. Each instrument shall be marked with a calibration sticker showing the date of calibration, the date the next calibration is due, and the name of the person performing the calibration.

D. INSTRUMENT TYPE FOR USE

The instrument used to survey for radiation shall be the correct type to detect the radiation in question. For most purposes, a G-M "pancake" detector is preferred. Phosphorous-32 and -33, Sulfur-35, and Carbon-14 may be detected with a "pancake" probe or a thin end-window detector. Carbon-14 emits a relatively weak beta; therefore, a survey should proceed carefully and slowly to allow detector response. Tritium (Hydrogen-3) use areas must be surveyed using wipes that can be analyzed in a liquid scintillation counter or special detector approved by the RSO. Radionuclides which emit gamma radiation or a combination of beta and gamma, such as Iodine, Cesium-137, and Cobalt-60, may be surveyed with a Geiger-Muller tube or ionization chamber. Any radionuclide or combination of isotopes which emits alpha or neutron radiation must be surveyed with a detector approved by the RSO.

Information regarding the selection of radiation survey instrumentation in provided in Appendix VII. If any questions arise regarding the type of detector to be used to perform a survey, contact the RSO for advice and assistance.

VI. LEAK TESTS OF SEALED SOURCES

A. GENERAL

The License issued by the Arkansas Department of Health requires that sealed sources be tested for leakage at intervals not to exceed certain time periods and that records are maintained of the results of these tests.

B. LEAK TESTS

The RSO is responsible for scheduling and conducting leak tests on sealed sources. When a leak test is due, the RSO or a member of the staff of the Radiation Safety Section will make arrangements with the Authorized User to perform the test.

The University performs leak tests using commercial leak test kits provided by companies providing leak test services under a license issued by the Arkansas Department of Health, another Agreement State, or the U. S. Nuclear Regulatory Commission for such services. The RSO or a trained member of the Radiation Safety Section will collect the leak test samples using the procedures and sample collection media provided by the leak test service provider. Once collected they are returned to the leak test service provider for analysis and reporting of the results back to the University.
With an exception to the above, Ni-63 sources will be tested by RSO or a trained member of the Radiation Safety Section using sterile 6-inch cotton tipped applicator. Such leak tests will be performed by the Radiation Safety Staff in the EH&S Radiation lab using Perkin-Elmer Liquid Scintillation Counter, Model: Tri-Carb 4910TR.

Records of the result of each leak test are maintain by the RSO.

VII. MONITORING OF PERSONNEL RADIATION EXPOSURE

The University is required by the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation*) to monitor the radiation exposure of each individual who is occupationally exposed to sources of radiation under the control of the University. This monitoring includes both external exposure (i.e., exposure resulting from radionuclides outside of the body of the exposed individual) and internal exposure (i.e., exposure resulting from radionuclides taken into the body of the individual).

The RSO is responsible for providing and maintaining the personnel radiation monitoring programs necessary to meet these requirements.

A. EXTERNAL RADIATION MONITORING

Individuals working in laboratories and other work areas at the University are monitored with whole-body dosimeters and/or finger ring dosimeters, if appropriate. Thermo-luminescence dosimeters (TLD) supplied by a commercial supplier accredited by the National Institute of Standards and Technology (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) are used by the University.

The RSO and Radiation Safety provide a centralized program for the purchasing, distribution, and collection of personnel dosimeters for the University. Reports of exposures reported by the commercial supplier are maintained by the RSO.

At the present time most individuals are assigned TLD badges which are issued and collected on a quarterly frequency. If appropriate, shorter wear periods may be used if larger quantities of radionuclides are used.

The RSO shall ensure that applicants for University Authorization have selected appropriate personnel dosimetry devices for the activities be conducted under the University Authorization prior to the issuance of the University Authorization.

In general, the following guidelines for selection of dosimetry devices will be used for.

1. Laboratories and other work areas where Cesium-137 (Cs-137), Chromium-51 (Cr-51), Iodine-125 (I-125), Fluorine-18 (F-18) or other gamma emitters are used - Individuals will be issued whole body dosimeters.

2. Laboratories and other work areas where Phosphorus-32 (P-32) or other energetic beta emitters are used - Individuals will be issued whole body and finger ring dosimeters.

3. Laboratories and other use areas where only Tritium (H-3), Carbon-14 (C-14), Phosphorus-33 (P-33), Sulfur 35 (S-35) and/or Calcium-45 (Ca-45) are used - Individuals do not require external personnel monitoring and will not be issued badges.

4. Special radiation monitoring may be provided for pregnant workers. The University will make accommodations for declared pregnant women to minimize doses to the unborn. For workers with a declared pregnancy, fetal monitoring badges are provided. These will be exchanged monthly.

In certain circumstances direct-reading pocket ion-chamber detectors may be used to supplement the monitoring by TLD devices. These can be used to provide a daily indication of external radiation exposure and may be utilized by visitors to laboratories and other work areas. Direct-reading pocket ion-chamber detectors must be used with a charger/reader device and zeroed before each use. Pocket dosimeters are intended to supplement rather than to replace TLD dosimetry. They are not used for routine dose monitoring.

Pocket dosimeters may be used at the University in order to get an indication of the accumulated radiation exposure on a daily basis. This exposure information may be used to alter work assignments when necessary to reduce and minimize radiation exposure.

The Authorized User shall ensure that a log is maintained of pocket dosimeter usage. The log shall include the name of the wearer, his/her SSAN/ID, pocket dosimeter used (make, model, and serial number), the date worn (pocket should not be worn for a period exceeding one day between readings), times worn, and the dose recorded by the dosimeter. A copy of these logs shall be forwarded to the RSO who shall maintain a file of these logs.

Only calibrated pocket dosimeters shall be used at the University.

The following guidelines shall be used in calibrating pocket dosimeters.

1. Calibration of pocket dosimeters shall be performed annually at intervals not to exceed 12 months.

2. Zero (recharge) the dosimeter(s) and record the serial number.

3. Allow at least 24 hours to pass, then read and re-zero the dosimeter. Dosimeters exhibiting leakage rates of greater than 4 milliRoentgens during the 24 hours shall be recorded as "Failed". Dosimeters failing leak tests shall be repaired and recalibrated prior to being placed back into service.

4. Dosimeters which pass the leak test will be sent to a licensed commercial calibration firm for calibration.

5. If the error is less than or equal to 10% and the leakage rate is less than or equal to 4 milliRoentgen in 24 hours, the dosimeter shall be considered to have passed calibration. If the dosimeter fails one or more of these tests, it shall be considered failed and shall not be used until repaired and successfully recalibrated.

B. BIOASSAYS

Although currently no bioassay program is required for programs with University Authorizations, the Radiation Safety Section maintains the capability to conduct a bioassay program. If a bioassay measurement is required for a program, the requirement for that program will be contained in the University Authorization issued to the Authorized User.

In general, programs that use more than 100 millicuries of tritium (Hydrogen-3) or 10 millicuries of radioisotopes of iodine in an unsealed form shall be required to participate in the bioassay program.

The Radiation Safety Section shall conduct the program of bioassay sample collection and analysis using the methods and procedures in U.S. Nuclear Regulatory Commission Regulatory Guide 8.9, Revision 1: *Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program*.

The results of all bioassays shall be maintained on file by the RSO.

VIII: PERSONNEL TRAINING PROGRAM

Each individual working in a laboratory or other area in which radionuclides or ionizing radiation producing equipment are used is required to complete radiation safety training prescribed by the University. First time users of radionuclides and/or ionizing radiation producing equipment are required to complete an in-person Users Training before

beginning work with a radionuclide or ionizing radiation producing equipment. Annual refresher training through BioRAFT is also required for all users.

The RSO will schedule and conduct the training sessions with assistance from other qualified individuals as appropriate and utilize the EHS information management system (BioRAFT) to deliver and track training as appropriate for initial and refresher training.

A. TRAINING FOR FIRST TIME USERS

1. Duration of Training – 4 hours

2. Course Modules:
    a. Properties of radiation
    b. Background radiation and other sources of radiation exposure
    c. Biological effects of radiation
    d. Government regulations and the University's Radiation Safety Manual
    e. External and internal radiation dose limits
    f. Radiation monitoring

These modules provide information on the following topics:

- The basic characteristics of radiation, including the properties of various radioactive emissions
- Radioactive half life
- Radiation units
- Natural background radiation and other sources of radiation exposure
- Biological effects of radiation exposure
- Risks of radiation exposure
- Rules and regulations of Arkansas Department of Health
- University of Arkansas Radiation Safety Manual and administration of the radiation safety program
- Annual radiation dose limits
- ALARA philosophy
- When radiation dosimetry badge is required and when is not
- Declared pregnant worker program
- Methods of controlling radiation dose
- Radiation detection and survey methods
- Radiation safety practices
- Radiation caution signs and security
- Radioactive waste management
- Emergency response

In addition to the topics listed above, instruction in the "Procedures for Laboratory Animal Uses" (Appendix III) shall be given to each user working in laboratories involving the use of live animals.

3. Materials

A Power Point Presentation, including hard copy handouts, is given covering all the above topics. In addition to the power point presentation, hands-on demonstrations using survey meters, check sources, whole body and ring TLD badges, smear or wipe sample collection media, and other accessories are conducted.

At the end of class, all participants must take a quiz. In order to pass the training, a participant must score 90% or above. If a participant scores less than 90%, the participant may take the quiz a second time. If a score of less than 90% is made on the second attempt, the participant must repeat the training prior to taking the quiz again.

In no case shall an individual be named as a user on a University Authorization prior to passing the quiz.

4. Authorized User responsibility

In addition to the RSO training sessions, each Authorized User must provide a review session for his/her radiation workers. The Authorized User will maintain a record of this training which includes the date, names of attendees, and topics covered.

The topics for this training shall include at least the following topics:

- Description of laboratory's work involving radionuclides
- Proper work procedures and habits
- Radiation exposure control
- Record keeping
- Emergency response procedures

B. REFRESHER TRAINING

All individuals working with radionuclides and/or ionizing radiation producing equipment shall undergo an annual radiation safety refresher training either in a training class or online training through BioRAFT. The RSO will schedule and conduct the refresher training classes as needed.

The refresher training class shall be:

1. Duration of training – 2 hours

2. Topics to be covered
   - Review of University Radiation Safety Manual and Program
   - Review of the most recent Arkansas Department of Health inspection

3. Materials

- Summary of inspection
- Summary of Radiation Safety Program

The web-based (BioRAFT) online training is available on the Environmental Health and Safety page on the University website. Individuals with a University identification number get access to the website for the refresher training. The modules of the web-based training are: 1 – X-Ray Safety, and 2 – Radiation Safety, which covers the following groups:

- Ancillary personnel radiation safety training for firefighters, police officers, janitorial, and other staff who encounter radiation occasionally.
- Radiation safety for all open source users.
- Sealed source safety for all sealed source users.

IX: WASTE DISPOSAL

A. PROCEDURES FOR RADIOACTIVE WASTE HANDLING BY AUTHORIZED USERS

All radioactive waste should be segregated by radionuclide and physical and/or chemical form. All radioactive wastes shall be stored in containers with appropriate labeling and adequate shielding. The Authorized User should contact the RSO regarding proper containers, labeling, and segregation of radioactive waste.

Under no circumstance shall an Authorized User dispose of any radionuclides via the sanitary sewer unless that disposal is specifically permitted in the University Authorization issued to that Authorized User.

Waste Types

Type	Examples	Containers
Dry	Gloves, absorption papers	Plastic bags
Liquid	Wash solutions	Polyethylene or carboy bottles with lids. Spill control trays (Glass bottles may be used)
LSC	LSC vials with cocktail & sample	Original cardboard box or doubled plastic bags
Biowaste	Carcasses, tissue	Plastic bags

The following are general considerations for managing radioactive waste.

1. Segregate radionuclides by half-life and physical form. Liquid and solid waste must be collected separately. In addition, waste must be

segregated based on the radionuclide's half-life (waste with radionuclides with half lives less than 90 days may be stored together and those with half lives more than 90 days may be stored together.) All liquid containers must have secondary containers to contain potential spills.

2. Sharps (needles, scalpels, broken glass, etc.) must be put into puncture-resistant containers *before* being placed in waste barrels.

3. Do not place lead shielding containers (pigs) in waste barrels.

4. Aqueous waste must be treated to attain a pH between 5 and 9 before disposal.

5. Liquid containers should be only 2/3 full, and the cap should be tightly closed.

6. Gloves worn during the handling of radionuclides will be removed before handling paperwork.

7. Wastes may be stored in a designated area of the laboratory until picked up by the RSO or staff from the Radiation Safety Section.

B. PROCEDURE FOR PICK-UP AND HANDLING OF RADIOACTIVE WASTE BY RADIATION SAFETY

1. The Authorized User should contact the Radiation Safety Section to arrange radioactive waste pick-ups using BioRAFT.

2. The RSO or qualified staff of Radiation Safety shall pick-up the radioactive waste. At the time of the pick-up, the date, time, and amount of radioactive waste will be recorded and the following information regarding the radioactive waste should be obtained from the Authorized User:

   a. Radionuclide(s)
   b. Estimated activity
   c. Date of closure of the container
   d. Authorized User and/or contact person
   e. Any information regarding potential hazards (e.g., chemical, biological) or other factors related to the safe handling of the radioactive waste

3. All generated radioactive waste from campus laboratories will be transported to and stored in room 104, Environmental Health and Safety Storage Building at 1530 West Mitchell Street, Fayetteville, Arkansas 72701, awaiting further waste processing and/or shipment for disposal.

4. All radioactive waste disposals should be conducted by the RSO or under his/her supervision.

5. Short-lived radionuclides (Half-life less than or equal to 90 days)
These radioactive wastes will be stored for a period of a minimum of ten half-lives. If radiation surveys of the waste at the end of the holding period indicate that radiation levels are indistinguishable from background, these may be disposed of in ordinary trash or as chemical/biological waste, if appropriate. All radiation labels will be defaced or removed from containers and packages prior to disposal as ordinary trash. For compacted waste, all levels that are visible in the compacted mass must be defaced or removed.

6. Long-lived nuclides (Half-life longer than 90 days)

Liquid scintillation medium containing no more than 0.05 microcurie per gram of Hydrogen 3 or Carbon 14 and animal carcasses or tissues containing no more than 0.05 microcurie per gram (averaged over the weight of the entire sample) may be treated as non-radioactive waste. Others will be kept in storage for periodic pick-ups.

7. All other radioactive waste containing radionuclides with a half-life greater than 90 days will be disposed of through a properly licensed/permitted radioactive waste broker and/or radioactive waste disposal/treatment site.

8. All radioactive waste shipped off-site from the University shall be prepared and packaged by the RSO and/or staff of Radiation Safety in accordance with the applicable rules and regulations of the U. S. Department of Transportation and the Arkansas Department of Health.

X: PUBLIC DOSE AND ENVIRONMENTAL MONITORING

A. MONITORING OF LABORATORIES AND OTHER USE AREAS

Each laboratory and other use area where radionuclides are stored or used, including radioactive waste storage areas, will be posted with appropriate radiation warning signs as required by the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation*.

Each laboratory and other use area where radionuclides are stored or used will be either locked or under the direct surveillance of the Authorized User. No public access to these areas will be allowed.

To demonstrate compliance with the public dose limits (100 millirems per year), the following procedures will be followed:

(1) Appropriate warning signs and labels will be posted.

(2) All radionuclide use and storage areas will be locked or under the direct surveillance of the Authorized User to prevent general public access.
(3) Radiation surveys will be made outside all radionuclide use and storage areas to ensure that radiation levels are less than twice background or less than 2 millirems per hour in areas immediately adjacent to the use and storage areas.

(4) Swipes will be taken from doors that access each use and storage area and analyzed to ensure that the radioactive contamination level is less than 220 disintegrations per minute per 100 square centimeters.

(5) TLD badges will be placed adjacent to the entrance door(s) of the use and storage areas to monitor external radiation levels.

The results of routine survey and wipe test shall be maintained by the RSO. These results shall be reviewed by the RSO and outstanding results found are reported to Radiation Safety Committee.

B. MONITORING OF ENTOMBED ACCELERATOR VAULT

The RSO and/or staff of Radiation Safety shall take swipes for detectable amounts of tritium (hydrogen 3) in accessible areas at the entombed accelerator vault at least once for each calendar year, according to the new grid approved by ADH.

The results of these wipe tests shall be maintained by the RSO. These results shall be reviewed by the RSO and reported to Radiation Safety Committee each year.

XI: PROCEDURES FOR RADIATION EMERGENCIES AND INCIDENTS

A. GENERAL

A **radiation incident** is one that does not involve serious injury or death, fire, explosion, or a release of radionuclides which pose a significant threat to health or life

An ***emergency*** is an incident that involves serious injury or death, fire, explosion, or significant release of radionuclides that poses a threat to health or life, and which is or may be coupled with a minor or major radiological incident. **NOTIFY UNIVERSITY POLICE IMMEDIATELY IF AN EMERGENCY HAS OCCURRED by dialing (479) 575-2222 in accordance with the University's Environmental Health and**

Safety Hazardous Materials Emergency Plan. The RSO should be notified as soon as possible by calling (479) 263-2572.

In the event of an emergency in which radioactive materials are involved, the following procedure should be instituted:

1. Notify all persons in the area that an EMERGENCY has occurred and evacuate the area if a risk to persons is present.

2. Notify the University Police and the RSO of the nature of the emergency. Describe the number of persons involved and the location.

3. AWAIT THE EMERGENCY RESPONDERS who will assist and provide direction, as well as contact any other necessary responders.

In any radiation emergency or incident, personnel protection and emergency medical care have priority over radioactive decontamination of the building and equipment. In all cases, the RSO must be notified as soon as possible at (479) 575-5448 during normal work hours; after hours, call (479) 263-2572. Dial 911 for University Police if the emergency warrants it or the RSO cannot be contacted.

B. SEALED SOURCE RUPTURE

If the rupture of a sealed source occurs, or if potentially hazardous quantities of radioactive dusts, mists, fumes, organic vapors or gases are introduced into the air, the following emergency measures should be taken immediately:

1. No immediate attempt should be made to clean up the spill.

2. All doors should be closed and locked.

3. If powdered or gaseous sources are involved, the door and all other openings leading into the room should be sealed with wide masking tape and heavy wrapping paper.

4. The spread of radioactive contamination can be diminished by restricting the movements of potentially contaminated persons to a local zone just outside the spill area until the extent of shoe and clothing contamination is ascertained.

5. Every person who might have been contaminated should be monitored for radioactivity, and, if contaminated, should remove his/her outer clothes and be decontaminated. If no means are available for monitoring, it should be assumed that the person is contaminated.

6. The RSO shall be called immediately. If necessary, outside consultants experienced in radiation hazards may be called in for their advice and assistance in managing the incident.

C. RADIOACTIVE LIQUID SPILLS

All spills of radioactive material must be cleaned up promptly. The responsibility for cleaning or for calling for experienced help rests on the individuals working in the area involved and responsible for the spill. A major spill is defined as an uncontrolled and inadvertent release of radionuclides that exceeds 100 microcuries and does not involve airborne contamination. **Under no circumstances should any untrained person attempt to examine or clean up a major spill of radionuclides.** Fans or ventilating apparatus should not be turned on in an attempt to blow the radionuclides or decay products away. Such a maneuver will only spread the radionuclides throughout the area. If the radionuclides are blown out of a building, air currents may carry finely divided materials into nearby air-intake ducts. Taking proper precautions immediately will protect human life and reduce financial losses**. In the case of some radionuclides with long half-lives, expensive equipment or entire buildings may be rendered useless due to contamination.** When decontamination is possible it can run into millions of dollars, depending on the extent and nature of the contamination. Precautions taken in the first few minutes after an accidental release of radioactive material can mean the difference between inconvenience and disaster. The RSO shall be notified immediately of all accidents or incidents involving possible contamination of humans, ingestion of radionuclides by personnel, over-exposure to radiation, contamination of equipment, spread of contamination, or difficulty in cleaning up a contaminated area. The RSO must be notified immediately in the event of loss of radioisotopes.

D. MINOR SPILL

A *minor incident* with radionuclides is an abnormal occurrence involving low amounts (generally less than 100 microcuries) of radionuclides, where the worker handling the radionuclides knows how to clean it up, has the decontamination materials on hand, and can respond without incurring risk of exposures or spreading the contamination within a reasonably short time.

In the event of a minor incident, these procedures should be followed:

1. Notify the Authorized User and other persons in the room at once.

2. Permit only the minimum number of people necessary to deal with the spill into the area.

3. Contain the laboratory immediately, and if possible, also confine the spill.

4. Notify the RSO of the spill.

5. Wear protective gloves and drop absorbent paper on a liquid spill.

6. Decontaminate, using a radiation survey meter to check the progress of the work.

7. Monitor all persons involved in the spill and the cleaning.

E. MAJOR SPILL

A *major incident* is an abnormal occurrence involving larger amounts (generally greater than 100 microcuries) of radionuclides, high risk radionuclides, contamination of large areas, contamination of the skin of an individual, airborne radioactivity, or any situation where contamination may have been spread outside the authorized area. Major spills must be reported to the RSO immediately. Call the RSO at (479) 563-2572. In addition, if a major spill occurs during non-working hours, notify the University Police at 911.

In the event of a major incident, the following procedure should be instituted:

1. Notify all persons in the area that a major spill or incident has occurred and evacuate unnecessary personnel. Notify the Authorized User and the RSO.

2. If hands are protected from contamination (i.e., gloves), right the container of the spilled liquid. If possible, shield the source, but only if it can be done without significantly increasing your radiation exposure.

3. If the spill is on clothing, discard outer clothing at once.

4. Vacate the room and lock the doors in order to prevent entry.

5. If skin contamination has occurred, measure levels of contamination with a survey meter, record, and begin decontamination by gentle washing with warm water and soap, washing downwards towards extremities, not upwards.

F. LOSS OR THEFT OF RADIONUCLIDES

Any individual who determines that radionuclides have been stolen or lost shall immediately notify the RSO and the Authorized User of the loss or theft. The RSO shall notify the Arkansas Department of Health of the loss or theft as required by the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation.* The RSO shall notify the University Police and other response agencies and individuals as appropriate. The RSO shall conduct an investigation of the loss or theft and prepare a written report of the findings.

APPENDIX I

DEFINITIONS

DEFINITIONS

Except as noted below, these definitions are identical to those found in the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation.*

* Indicates definitions that have two or more similar definitions which been combined.

** Indicates where two or more dissimilar definitions have been retained with clarification.

Absorbed dose - The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

Act (Arkansas) - Act 8 of Second Extraordinary Special Session of 1961, as amended**.

Act (Federal) - The Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.), as amended**.

Activity - The rate of disintegration (transformation or decay of radioactive material. The units of activity) are the curie (Ci) and the becquerel (Bq).
For the purposes of this Part, activity is expressed in the special unit of curies (Ci) or in the SI unit of becquerels (Bq), or their multiples, or disintegrations (transformations) per unit of time.
a. One becquerel = 1 disintegration per second (s^{-1}).
b. One curie = 3.7×10^{10} disintegrations per second = 3.7×10^{10} becquerels = 2.22×10^{12} disintegrations per minute.

Adult - An individual 18 or more years of age.

Agreement State - Any State with which the U.S. Nuclear Regulatory Commission has entered into an effective agreement under Section 274 b. of the Atomic Energy Act of 1954 as amended (73 Stat. 689).

Airborne radioactive material - Radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

Airborne radioactivity area - A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations:
1. In excess of the derived air concentrations (DACs) specified in Appendix G to RH-1000. through RH-2110., or
2. To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

Air-purifying Respirator - A respirator with an air purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

ALARA (acronym for "as low as is reasonably achievable") – Making every reasonable effort to maintain exposures to radiation as far below the dose limits in this Part as is practical consistent with the purpose for which the licensed activity or x-ray equipment use is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of x-ray equipment, nuclear energy and licensed materials in the public interest.

Annual limit on intake (ALI) - The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table 1, Columns 1 and 2, of Appendix G to RH-1000 through RH-2110.).

Approved qualified expert - An individual who has, prior to offering health physics services, registered with and demonstrated to the satisfaction of the Department that he/she possesses the knowledge and training to measure ionizing radiation parameters, to evaluate safety techniques and to advise regarding radiation protection matters.

Assigned protection factor (APF) - The expected workplace level of respiratory protection that would be provided by a properly functioning respirator or a class of respirators to properly fitted and trained users. Operationally, the inhaled concentration can be estimated by dividing the ambient airborne concentration by the APF.

Atmosphere-supplying respirator - A respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere, and that includes supplied-air respirators (SARs) and self-contained breathing apparatus (SCBA) units.

Background radiation - Radiation from cosmic sources, naturally occurring radioactive materials, including Radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents such as Chernobyl that contribute to background radiation and are not under the control of the licensee or registrant.

Bioassay (radio-bioassay) - The determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

Byproduct material - Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Class (or lung class or inhalation class) - A classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days.

Collective dose - The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

Committed dose equivalent ($H_{T,50}$) - The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed effective dose equivalent ($H_{E,50}$) - The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50} = \Sigma\, w_T H_{T,50}$).

Constraint (dose constraint) - a value above which specified licensee or registrant actions are required.

Controlled area - An area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

Critical Group - the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.

Declared pregnant woman - A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared woman withdraws the declaration in writing or is no longer pregnant.

Decommission - to remove a facility or site safely from service and reduce residual radioactivity to a level that permits:
(1) Release of the property for unrestricted use and termination of the license; or
(2). Release of the property under restricted conditions and termination of the license*.

Deep-dose equivalent (H^d) - (which applies to external whole-body exposure) The dose equivalent at a tissue depth of one (1) cm (1000 mg/cm^2).

Demand respirator - An atmosphere-supplying respirator that admits breathing air to the facepiece only when a negative pressure is created inside the facepiece by inhalation.

Department - The Arkansas Department of Health or its duly authorized representative*.

Department of Energy (DOE) - The Department of Energy established by the Department of Energy Organization Act (Public Law 95-91, 91 Stat. 565, 42 U.S.C. 7101 et seq.) to the extent that the DOE, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers, and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to Sections 104 (b), (c), and (d) of the Energy Reorganization Act of 1974 (Public Law 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to Section 301(a) of the Department of Energy Organization Act (Public Law 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

Derived air concentration (DAC) - The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table 1, Column 3, of Appendix G to RH-1000 through RH-2110.

Derived air concentration-hour (DAC-hour) - The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

Director - Director of the Arkansas Department of Health**.

Disposable respirator - A respirator for which maintenance is not intended and that is designed to be discarded after excessive breathing resistance, sorbent exhaustion, physical damage, or end-of-service-life renders it unsuitable for use. Examples of this type of respirator are a disposable half-mask respirator or a disposable escape-only self-contained breathing apparatus (SCBA).

Distinguishable from background - the detectable concentration of a radionuclide is statistically different from the background concentration of that radionuclide in the vicinity of the site or, in the case of structures, in similar materials using adequate measurement technology, survey, and statistical techniques.

Dose or **radiation dose** - A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in other Paragraphs of this Section.

Dose equivalent (H_T) - The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dosimetry processor - An individual or an organization that processes and evaluates individual monitoring equipment in order to determine the radiation dose delivered to the equipment.

Effective dose equivalent (H_E) - The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (w_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma\, w_T H_T$).

Embryo/fetus - The developing human organism from conception until the time of birth.

Entrance or access point - Any location through which an individual could gain access to radiation areas or to radioactive materials. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

Exposure - Being exposed to ionizing radiation or to radioactive material.

External dose - That portion of the dose equivalent received from radiation sources outside the body.

Extremity - Hand, elbow, arm below the elbow, foot, knee, and leg below the knee.

Eye dose equivalent - The external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

Filtering facepiece (dust mask) – A negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium, not equipped with elastomeric sealing surfaces and adjustable strap.

Fit factor – A quantitative estimate of the fit with a particular respirator to a specific individual, and typically estimates the radio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.

Fit test – The use of a protocol to qualitatively or quantitatively evaluate the fit of a respirator on an individual.

Generally applicable environmental radiation standards - Standards issued by the Environmental Protection Agency (EPA) under the authority of the Atomic Energy Act of 1954, as amended, that impose limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.

Government agency - Any executive department, commission, independent establishment, corporation wholly or partly owned by the United States of America, which is an instrumentality of the United States, or any board, bureau, division, service,

office, officer, authority, administration, or other establishment in the executive branch of the Government.

Gray - See Units of Radiation Dose.

Helmet - A rigid respirator inlet covering that also provides head protection against impact and penetration.

High radiation area - An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in one (1) hour at thirty 30 centimeters from the radiation source or thirty (30) centimeters from any surface that the radiation penetrates.

Hood - A respiratory inlet covering that completely covers the head and neck and may also cover portions of the shoulders and torso.

Individual - Any human being.

Individual monitoring:
1. The assessment of dose equivalent by the use of devices designed to be worn by an individual;
2. The assessment of committed effective dose equivalent by bioassay (see Bioassay) or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours; or
3. The assessment of dose equivalent by the use of survey data.

Individual Monitoring Devices (individual monitoring equipment) - Devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), pocket ionization chambers, and personal ("lapel") air sampling devices.

Inspection - An official examination or observation including but not limited to, tests, surveys and monitoring to determine compliance with rules, regulations, orders, requirements and conditions of the Department.

Installation - The location where one or more reportable sources of radiation are used, operated or stored.

Internal dose - That portion of the dose equivalent received from radioactive material taken into the body.

Lens dose equivalent (LDE) - applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

License - Except where otherwise specified, means a license issued pursuant to Section 2, Section 6, or Section 7 of the Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation***.

Licensed material - Source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the Department.

Licensee - The holder of a license.

Limits (dose limits) - The permissible upper bounds of radiation doses.

Loose-fitting facepiece - A respiratory inlet covering that is designed to form a partial seal with the face.

Lost or missing licensed material - Licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

Member of the public – Any individual except when that individual is receiving an occupational dose or unrestricted area.

Minor - An individual less than 18 years of age.

Monitoring (radiation monitoring, radiation protection monitoring) – The measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

Negative pressure respirator (tight fitting) -- A respirator in which the air pressure inside the facepiece is negative during inhalation with respect to the ambient air pressure outside the respirator.

Non-stochastic effect - Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a non-stochastic effect (also called a deterministic effect).

Occupational dose - The dose received by an individual in course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, from any medical administration the individual has received from exposure to individuals administered radioactive material and released in accordance with RH-1214, from voluntary participation in medical research programs, or as a member of the general public.

Person - Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, agency, political subdivision of this State, any other State or political subdivision or agency thereof and any legal successor, representative, agent or agency of the foregoing, other than the U.S. Nuclear Regulatory Commission and other federal government agencies.

Planned special exposure - An infrequent exposure to radiation, separate from and in addition to the annual dose limits.

Positive pressure respirator - a respirator in which the pressure inside the respiratory inlet covering exceeds the ambient air pressure outside the respirator.

Possessing a source of radiation - Using, operating, storing, manufacturing or otherwise having control of a source of radiation in the State of Arkansas.

Powered air-purifying respirator (PADR) - an air-purifying respirator that uses a blower to force the ambient air through air-purifying elements to the inlet covering.

Pressure demand respirator - a positive pressure atmosphere-supplying respirator that admits breathing air to the facepiece when the positive pressure is reduced inside the facepiece by inhalation.

Public dose - The dose received by a member of the public from exposure to radiation or radioactive material released by a licensee, or to any other source of radiation under the control of a licensee or registrant. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with RH-1214, or from voluntary participation in medical research programs.

Qualitative fit test (QLFT) - A pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.

Quality Factor (Q) - The modifying factor (listed in Tables 1 and 2 of RH-1102.) that is used to derive dose equivalent from absorbed dose.

Quantitative fit test (QNFT) – means an assessment of the adequacy of respirator fit by numerically measuring the leakage into the respirator.

Quarter - A period of time equal to one-fourth of the year observed by the licensee (approximately 13 consecutive weeks), providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.

Rad - See Units of Radiation Dose.

Radiation (ionizing radiation) - Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this Part, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light*.

Radiation area - An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in one (1) hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates

Radiation machine - Any device that is capable of producing radiation, but it excludes devices that produce radiation only by the use of radioactive material*.

Radioactive material - Any material, solid, liquid, or gas which emits radiation spontaneously, including any natural radioactive material such as Radium.

Radioactivity - The transformation of unstable atomic nuclei by the emission of radiation.

Reference man - A hypothetical aggregation of human physical and physiological characteristics arrived at by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base.

Registrant - Any person who is registering or who has registered with the Department pursuant to these Regulations.

Rem - See Units of Radiation Dose.

Reportable source of radiation - Any source of radiation as specified under RH-20 of these Regulations.

Residual radioactivity - radioactivity in structures, materials, soils, groundwater, and other media at a site resulting from activities under the licensee's control. This includes radioactivity from all licensed and unlicensed sources used by the licensee, but, excludes background radiation. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site even if those burials were made in accordance with the provision of Section 3. Part E. Waste Disposal.

Respiratory protective device - An apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

Restricted area - An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Sanitary sewerage - A system of public sewers for carrying off waste water and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee.

Sealed Source - Radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal of the radioactive material under the most severe conditions which are likely to be encountered in normal use and handling.

Self-contained breathing apparatus (SCBA) - an atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.

Shallow-dose equivalent (H^s) - (which applies to the external exposure of the skin of the whole body or the skin of an extremity) - Is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2).

Sievert – See Units of Radiation Dose.

Site boundary - That line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

Source material -
1. Uranium or Thorium or any combination of Uranium and Thorium in any physical or chemical form; or
2. Ores that contain, by weight, one-twentieth of one (1%) percent (0.05 percent), or more, of Uranium, Thorium, or any combination of Uranium and Thorium.
Source material does not include special nuclear material.

Source of radiation - Any radioactive material or device or equipment (radiation machine) emitting or capable of producing any radiation*.

Special nuclear material -
1. Plutonium, Uranium-233, Uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Department, pursuant to the provisions of Section 51 of the Act, determines to be special nuclear material, but does not include source material, or
2. Any material artificially enriched by any of the foregoing but does not include source material.

Storage container - A device in which sealed sources are transported or stored.

Stochastic effects - Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Supplied-air respirator (SAR) or airline respirator - an atmosphere supplying respirator for which the source of breathing air is not designed to be carried by the user.

Survey - An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Temporary jobsite - a location to which radioactive materials or x-ray equipment have been dispatched to perform one (1) or more of the following service operations:
1. Moisture/density measurements;
2. Level measurements;
3. Any portable devices containing radioactive materials; and/or
4. Consulting services included, but not limited to:
A. Calibration of instruments;
B. Repair of devices or sources;
C. Sealed source installation and/or exchange;
D. Decommissioning of sealed sources.

These Regulations - Section 3, Rules and Regulations of the State Board of Health, Standards for Protection Against Radiation. AND/OR The Arkansas State Board of Health Rules and Regulations for Control of Sources of Ionizing Radiation, Section 1**.

Tight-fitting facepiece - a respiratory inlet covering that forms a complete seal with the face.

Total Effective Dose Equivalent (TEDE) - The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Uncontrolled area or **unrestricted area** - Any area to which access is not controlled by the licensee or registrant for the purposes of protection of individuals from exposure to radiation and radioactive materials and any area used for residential quarters.

Units of Radiation Dose.
As used in this Part, the units of radiation dose are:
a. Exposure rate - The exposure per unit of time, such as roentgen per minute and milliroentgen per hour.
b. Gray (Gy) - The SI unit of absorbed dose. One gray is equal to an absorbed dose of one (1) joule/kilogram (100 rads).
c. Rad - The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).
d. Rem - The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert).

e. Roentgen - the special unit of exposure. One roentgen (R) equals 2.58 x 10^{-4} coulombs/kilogram of air (See "Exposure" in RH-1100).
f. Sievert (Sv) - The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

Uranium fuel cycle - The operations of milling of Uranium ore, chemical conversion of Uranium, isotopic enrichment of Uranium, fabrication of Uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using Uranium fuel, and the reprocessing of spent Uranium fuel to the extent that these activities directly support the production of electrical power for public use. Uranium fuel cycle does not include mining operations, operations at waste disposal sites, transportation of radioactive material in support of these operations, and the reuse of recovered non-Uranium special nuclear and byproduct materials from the cycle.

User seal check (fit check) - an action conducted by the respirator user to determine if the respirator is properly seated to the face. Examples include negative pressure check, positive pressure, irritant smoke check, or isoamyl acetate check.

Very high radiation area - An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one (1) hour at one (1) meter from a radiation source or from any surface that the radiation penetrates.
Note: At very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems and sieverts).

Week - Seven (7) consecutive days starting on Sunday.

Weighting factor (w_T) - For an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective equivalent, the values of w_T are dose:

ORGAN DOSE WEIGHTING FACTORS

Organ or Tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30[a]
Whole Body	1.00[b]

[a] 0.30 results from 0.06 for each of 5 "remainder" organs (excluding the skin and the lens of the eye) that receive the highest doses.

[b] For the purpose of weighting the external whole body dose (for adding it to the internal dose), a single weighting factor, $w_T = 1.0$, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis

Whole body - For purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

Worker - An individual engaged in work under a license or registration issued by the Department and controlled by a licensee or registrant.

Working level (WL) - Any combination of short-lived Radon daughters (for Radon-222: Polonium-218, Lead-214, Bismuth-214, and Polonium-214; and for Radon-220: Polonium-216, Lead-212, Bismuth-212, and Polonium-212) in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy.

Working level month (WLM) - An exposure to one working level for 170 hours (2,000 working hours per year/12 months per year = approximately 170 hours per month).

Year - The period of time beginning in January used to determine compliance with the provisions of this Part. The licensee may change the starting date of the year used to determine compliance by the licensee provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

APPENDIX II

RADIONUCLIDE QUANTITIES OF CONCERN

RADIONUCLIDE QUANTITIES OF CONCERN

Radionuclide	Quantity of Concern[1] (TBq)	Quantity of Concern[2] (Ci)
Am-241	0.6	16
Am-241/Be	0.6	16
Cf-252	0.2	5.4
Cm-244	0.5	14
Co-60	0.3	8.1
Cs-137	1	27
Gd-153	10	270
Ir-192	0.8	22
Pu-239/Be	0.6	16
Ra-226	0.4	11
Se-75	2	54
Sr-90 (Y-90)	10	270
Tm-170	200	5,400
Yb-169	3	81
Combinations of radioactive materials listed above[3]	See footnote below[4]	

[1] The aggregate activity of multiple, collocated sources of the same radionuclide should be included when the total activity equals or exceeds the quantity of concern.

[2] The primary values used for compliance with this Table are TBq. The curie (Ci) values are rounded to two significant figures for informational purposes only.

[3] Radioactive materials are to be considered aggregated or collocated if breaching a common physical security barrier (e.g., a locked door at the entrance to a storage room) would allow access to the radioactive material or devices containing the radioactive material.

When transporting or storing sources on vehicles and/or trailers, the sources are automatically considered co-located.

[4] If several radionuclides are aggregated, the sum of the ratios of the activity of each source, i of radionuclide, n, A(i,n), to the quantity of concern for radionuclide n, Q(n), listed for that radionuclide equals or exceeds one. [(aggregated source activity for radionuclide A) ÷ (quantity of concern for radionuclide A)] + [(aggregated source activity for radionuclide B) ÷ (quantity of concern for radionuclide B)] + etc..... >1

APPENDIX III

PROCEDURES FOR LABORATORY ANIMAL USE

PROCEDURES FOR LABORATORY ANIMAL USE

This procedure provides additional information on the use of radionuclides in laboratory animals and in animals used for research in the environment.

Please note that any work involving live vertebrates must be approved by the Institutional Animal Care and Use Committee (IACUC).

Training

Before allowing an individual to care for animals used in studies with or treated with radionuclides, the RSO and Authorized User shall ensure that the user has sufficient training and experience to maintain doses ALARA, control contamination, and handle waste appropriately.

Classroom training will be in the form of lecture, videotape, and will cover the following areas:

- Principles and practices of radiation protection.
- Radioactivity measurements, monitoring techniques, and using instruments.
- Mathematics and calculations basic to using and measuring radioactivity.
- Biological effects of radiation.

Appropriate on-the-job-training will consist of:

- Observing authorized personnel using survey equipment, using proper contamination control techniques, and proper disposal of waste containing radionuclides.
- Using survey equipment, proper contamination control techniques, and proper disposal of radioactive waste procedures under the supervision of, and in the physical presence of, and individual authorized to handle animals containing radionuclides.

Contamination Control and Waste Handling

In order to minimize the spread of contamination, animals used in studies with or treated with radionuclides shall be housed in cages or stalls separate from other animals. The cages or stalls shall be secured to prevent unauthorized access to the animals. Individuals caring for these animals should reduce the chance of personal contamination by wearing gloves, lab coat, and eye protection, as appropriate.

Special care should be observed when cleaning the cage or stall. The cage or stall, the bedding, and waste from the animal may contain radionuclides. Any radioactive waste

should be properly disposed of as described in the section waste processing procedures for animal materials.

Disposal of laboratory animals that contain radionuclides require special procedures. Animal carcasses that contain less than 1.85 kBq/gram (0.05 microcurie/gram) of carbon-14 or hydrogen-3 may be disposed of by the same method as non-radioactive animal carcasses. Animal carcasses that contain radionuclides with a half-life of less than 90 days may be allowed to decay-in-storage in a freezer dedicated for storage of radionuclides. Animal carcasses will be held for a minimum of 10 half-lives of the longest-lived radionuclide. After 10 half-lives, the animal carcasses may be disposed as non-radioactive, if radiation surveys (performed in a low background area and without any interposed shielding) of the carcasses at the end of the holding period indicate that radiation levels are indistinguishable from background.

Animal Materials

- No animal waste will be picked up for disposal prior to suitable deactivation of infectious agents. Four types of radioactive waste are generated from animal experiments; bedding, dry, blood/urine, and carcasses. Each type is to be segregated and prepared for disposal.
- Bedding
    1. This consists of bedding material only. Bedding is to be double bagged in plastic bags.
    2. Separate the bedding material by the half-life of the radionuclide that was used on the animal.
- Solid or dry radioactive waste will be handled in accordance with Section IX of this Manual.
- Blood/Urine
    1. Collect blood/urine separately in plastic container.
    2. The bulk liquid waste will be handled with Section IX of this Manual.
- Carcasses
    1. Separate carcasses with a half-life less than 90 days and place them in double-bagged plastic bags.
    2. Separate carcasses which contain less than 0.05 microcuries per gram of tritium (hydrogen 3) and carbon 14. These carcasses should be placed in double-bagged plastic bags with as much of the air removed as possible.
    3. Separate carcasses containing any other radionuclides and place them in doubled-bagged plastic bags.
    4. All carcasses should be kept frozen until Radiation Safety picks them up.
- The outer bag must be labeled or tagged with radionuclide, activity, and date of the last addition of waste.

APPENDIX IV

Radiological Safety Audit FORM

Office of Environmental Health and Safety
521 South Razorback Road, Fayetteville, Arkansas 72701
Phone: 479-575-5448 Fax: 479-575-6474

Radiological Safety Audit

Building: _____ **Room:** _____ **Date:** _____

Person Responsible for Area: _____

SIGNAGE/ACCESS				
Items Inspected	**Y**	**N**	**N/A**	**Comments**
1. Is there limited access, controlled by PI, to the radiation area?				
2. Are specific hazard warnings posted on entry door (NFPA worst case)?				
3. Are radiation warning labels posted in the radiation use, storage or disposal area?				
4. Is PI contact information posted properly?				
5. Is emergency contact information readily available?				
6. Is the signage on the door and inside the lab correct?				
7. Is Ark Notice to Employee form EHAR02 signage conspicuously posted?				
8. Is Ark Notice to Employee form EHAR02 current form?				
FRIDGE & FOOD				
9. Is the Refrigerator properly labeled (e.g. no food storage, no flammable storage) and spark proof where appropriate?				
10. Are 'No Food/Drink' signs conspicuously posted?				
11. Is there evidence of eating and drinking in the lab?				
SINK				
12. Is radioactive sink properly posted?				
13. Do personnel wash hands after work/prior to leaving radionuclide area?				
FUME HOOD				
14. Are fume hoods (1) Regular hood ANSI Z9.5-1992 (2) Low Flow/High Efficiency ASHRAE 110 Protocol?				
15. Are radioactive materials used appropriately in fume hoods?				
PPE AND RADIATION BADGES				
16. Is suitable PPE used in the lab?				
17. Are appropriate gloves available and worn?				
18. Are radiation badges current and worn appropriately?				
RADIOLOGICAL WASTE				
19. Is radioactive waste disposed in a timely manner?				
20. Is radioactive waste handled appropriately?				
21. Is radioactive waste properly segregated/stored according to Section IX of the UA Radiation Manual?				
22. Are radioactive waste tags complete and present?				
23. Is radioactive waste storage area clearly posted?				

RADIOLOGICAL				
Items Inspected	**Y**	**N**	**N/A**	**Comments**
24. Are the regular trash and glass recycling free of radioactive waste?				
25. Does the lab follow ALARA radiation dose practices?				
26. Is inventory of radioactive material in possession current?				
27. Are laboratory contamination tests for radiological hazard available?				
28. Is the LSC/gamma counter working?				
29. If required, is shielding used?				
30. Is the correct radiation meter selected for use in radiation area as per Section D of UA Radiation Manual?				
31. Is the radiation meter calibration current?				
32. Is the radiation meter functioning properly?				
33. Are hands and lab coats tested with Rad meter upon completion of radiation work?				
34. Are required radiation protocol documents available?				
35. Are radiation use areas demarcated clearly?				
36. Are radiation work surfaces/trays protected by plastic backed absorbent paper?				
37. Is radioactive material adequately security?				
38. Are radioactive material receipt, usage and disposal records current?				
39. Are radiation working areas surveyed after use to see if contamination is present with the appropriate/calibrated counter?				
40. Are survey and wipes being recorded?				
41. Are there materials and supplies handy to clean up minor spills per Section XI of the UA Radiation Manual?				
TRAINING				
42. Is initial hazardous waste training current?				
43. Is radiation safety training completed by the research/ lab group current?				

Auditor: _____

APPENDIX V

Radioactive Material Laboratory Survey FORM

Radioactive Material Laboratory Survey

Lab Number : _____ **Department** : _____
Authorized user : _____ **Isotope Used** : _____
Surveyor Name : _____ **Date** : _____

Nuclides used and swipe result (cpm/100cm^2) / GM survey

BG			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Meter used for the frisk survey

Make _____ Model _____ Serial# _____Calibration date: _____

Probe type _____ Probe model _____ Probe serial # _____

Surveyor's signature: _____
Date: _____

AU/AU representative: _____ Signature: _____

Date: _____

FORM (Revised October 2018)

APPENDIX VI

APPLICATION TO USE RADIONUCLIDES

APPLICATION TO USE RADIONUCLIDES

UNIVERSITY OF ARKANSAS
ENVIRONMENTAL HEALTH & SAFETY
RADIATION SAFETY SECTION

This form shall be completed and returned to the Radiation Safety Officer (RSO). (It is suggested that an electronic draft be submitted to the RSO for review and comment prior to obtaining the required signatures.) Only upon notification of approval use of radionuclides shall be permitted. Please type or electronically submit this form. Hand-written forms will not be accepted.

University of Arkansas
FORM 1 - APPLICATION FOR RADIONUCLIDE USE

APPLICATION CLASS: [ ] New [ ] Renewal [ ] Amendment Date: .

1. TITLE OF PROJECT:

2. INVESTIGATOR NAME: **DEPT.:**
TITLE: **PHONE**:
Campus Address:

a. Name & title of others who will work on this project (complete supplemental training sheet for each):
NAME: **DEPT.:**
TITLE: **PHONE**:
Campus Address:

3. Radioactive materials to be used:

Nuclide	Physical / Chemical forms	Maximum amount in possession (mCi)

4. RADIONUCLIDE USAGE AND DISPOSAL:
a. Location(s) of use:
b. Location(s) of storage:
c. Duration of Usage:
d. Ci/experiment:
e. Waste Disposal [1]:

	mCi/month and volume (gals. or lbs.)			
Nuclide	**Dry Waste**	**Liquid Scint.**	**Aqueous Liquid**	**Non-aqueous liquid**

Note 1: Review rules for radioactive waste disposal.

Applicant Signature: **Date:**

DATE RECEIVED: **DATE APPROVED:**

University of Arkansas - APPLICATION FOR RADIONUCLIDE USE (Form 1, continued)

1. DESCRIPTION OF HOW RADIONUCLIDES WILL BE USED (Give special attention to procedures that have potential of contamination - centrifugation, evolution of gases, vapors, etc.):

Applicant Signature: _____ **Date:** _____

(Form 1, continued)

1. RADIATION SAFETY PROCEDURES TO BE FOLLOWED, FACILITIES & EQUIPMENT, ETC.
(Attach separate pages as necessary).

a. Procedures to ensure radionuclides are not lost or stolen.

b. Posting and labeling practices.

c. Contamination control measures (trays, gloves, adsorbent paper, etc.).

d. Fume hood availability.

e. Radiation survey meter availability.
. **Survey meter type:**

Probe Type:

f. Shielding devices.

g. Personnel Dosimetry.
_____Ring badge_____Body badge_____Bioassay_____Others

h. Other.

Applicant Signature: _____ **Date:** _____

FORM 2 - TRAINING AND EXPERIENCE SUPPLEMENT (Attach to Form 1)

1. NAME: **TITLE:** **DEPT.:**

BIRTHDATE: **SEX:**

2. FORMAL TRAINING:

a. List Dates and Institution(s):

b. List number of clock hours for each of the following subjects covered (20 hours total required for P.I.):

Hours	Subject
	Principles of radiation safety
	Radiation measurement, monitoring techniques and instruments
	Mathematics & calculations basic to use and measurement of radiation
	Biological effects of radiation
	Other (specify)
	Total hours

c. Is a copy of certification of training attached to application? yes no

3. EXPERIENCE WITH RADIATION SOURCES:

a. Dates and Institution(s):

b. Nuclide Maximum amount (mCi) Type of use

4. RADIATION EXPOSURE HISTORY: Give address(es) of facilities where you have been issued personnel monitoring (film badges, ring badges, other dosimeters) or where bioassays (thyroid uptake, urinalysis) have been performed. (Include dates).

Date(s) Monitoring type Bioassay type Facility and address

5. CERTIFICATION: I certify that the above information is correct to the best of my knowledge and I authorize release of my previous radiation exposure history as described above.

SIGNATURE: **DATE:**

Signature of the Departmental Chair **Date:**

Name of the Departmental Chair

APPENDIX VII

RADIONUCLIDES:

DATA AND INFORMATION

HYDROGEN-3

[^{3}H]

PHYSICAL DATA

Beta Energy:	18.6 keV (maximum)
	5.7 keV (average) (100% abundance)
Physical Half-Life:	12.3 years
Biological Half-Life:	10-12 days
Effective Half-Life:	10-12 days *

*Forcing liquids to tolerance (3-4 liters/day) will reduce the effective half-life of ^{3}H by a factor of 2 or 3. (Relatively easy to flush out of system with fluids.)

Specific Activity:	9,640 Ci/gram
Maximum Beta Range in Air:	6 mm = 0.6 cm= ¼"
Maximum Beta Range in Water:	0.006 mm = 0.0006 cm = 3/10,000"
Penetrability in Matter or Tissue:	Insignificant*

*[0% of beta particle energy transmitted through dead layer of skin]

RADIOLOGICAL DATA

Least radiotoxic of all radionuclides
Critical Organ: Body Water or Tissue
Routes of Intake: Ingestion, Inhalation, Puncture, Wound, Skin Contamination (absorption)
External exposure from weak ^{3}H beta energy – not a radiological concern
Internal exposure & contamination are primary radiological concerns

Committed Dose Equivalent (CDE):	64 mrem/mCi (ingested)
	64 mrem/mCi (inhaled)
	64 mrem/mCi (puncture)
Committed Effective Dose Equivalent (CEDE):	90 mrem/mCi (ingested)
	63 mrem/mCi (inhaled)
Annual Limit on Intake (ALI)*:	80 mCi (ingestion or inhalation) [^3H_2O]]

*[1.0 ALI = 80 mCi (^{3}H) = 5,000 mrem CEDE]

Skin Contamination Exposure Rate: 57,900 mrad/hr/mCi (contact)*

* Exposure rate to dead layer of skin only.
* Skin contamination of 1.0 uCi/cm^2 = 0 mrad/hr dose rate to basal cells

Rule of Thumb: 0.001 uCi/ml of ^{3}H in urine sample is indicative of a total integrated whole body of approximately 10 mrem (average person) if no treatment is instituted (i.e., flush with fluids); [NCRP-65, 1980]

SHIELDING

None required

SURVEY INSTRUMENTATION

CANNOT detect ^{3}H using a G-M or NaI survey meter
Liquid scintillation counter (indirect) is the only monitoring method

CARBON-14
[^{14}C]

PHYSICAL DATA

Beta Energy:	156 keV (maximum) 49 keV (average) (100% abundance)
Physical Half-Life:	5,730 years
Biological Half-Life:	12 days
Effective Half-Life:	12 days (Bound)
Effective Half-Life:	40 days (Unbound)
Specific Activity:	4,460 mCi/gram
Maximum Beta Range in Air:	24.00 cm = 10 inches
Maximum Beta Range in Water/Tissue:	*0.28 mm = 0.012 inches
Maximum Range in Plexiglas/Lucite/Plastic:	0.25 mm = 0.010 inches

*Fraction of ^{14}C beta particle transmitted through dead layer of skin: At 0.007 cm depth = 1%

RADIOLOGICAL DATA

Critical Organ:	Fat Tissue
Route of Intake:	Ingestion, Inhalation, Skin Contact
External exposure:	Deep dose from weak ^{14}C beta particles is not a radiological concern
Internal exposure & contamination:	primary radiological concerns
Committed Dose Equivalent (CDE): (Fat Tissue)	2.08 mrem/uCi (ingested) 2.07 mrem/uCi (puncture) 1.09 mrem/uCi (inhalation)
Committed Effective Dose Equivalent (CEDE):	1.54 mrem/uCi (ingested)
Annual Limit on Intake (ALI)*:	2 mCi (ingestion of labeled organic compound) 2,000 mCi (inhalation of carbon monoxide) 200 mCi (inhalation of carbon dioxide)

*[1.0 ALI = 2 mCi (ingested C-14 organic compound) = 5,000 mrem CEDE]

Skin Contamination Dose Rate: 1,090-1,180 mrem per 1.0 uCi/cm^2 (7 mg/cm^2 depth)
Dose Rate to Basal Cells from Skin Contamination 1.0 uCi/cm^2 = 1400 mrad/hour.

SHIELDING

None required

SURVEY INSTRUMENTAION

Can detect ^{14}C using a thin window G-M survey meter probe must be at close range (1 cm.)

G-M survey meters have very low counting efficiency for ^{14}C (5%)

Liquid scintillation counter (indirect counting) may be used to detect removable ^{14}C on wipes

PHOSPHORUS-32
[^{32}P]

PHYSICAL DATA

Beta energy:	1.709 MeV (maximum) 0.690 MeV (average, 100% abundance)
Physical half-life:	14.3 days
Biological half-life:	1,155 days
Effective half-life:	14.1 days (bone)/13.5 days (whole body)
Specific activity:	285,000 Ci/gram
Maximum range in air:	610 cm = 240 inches = 20 feet
Maximum range in water/tissue:	0.72 cm = 1/3 inches
Maximum range in Plexiglas:	0.61 cm = 3/8 inches

RADIOLOGICAL DATA

Critical organ (biological destination) (soluble forms): Bone
Critical organs (insoluble forms or non-transportable ^{32}P compounds): Lungs (inhalation) and G.I. tract/lower large intestine (ingestion)

Routes of intake: Ingestion, inhalation, puncture, wound, skin contamination (absorption)

External and internal exposure from ^{32}P

Committed Dose Equivalent (CDE):	32 mrem/mCi (ingestion) 37 mrem/mCi (puncture) 96 mrem/mCi (inhaled/Class W/lungs) 22 mrem/mCi (inhaled/Class D/bone marrow)
Committed Effective Dose Equivalent: (CEDE)	7.50 mrem/Ci (ingested/WB) 5.55 mrem/Ci (inhaled/Class D) 13.22 mrem/Ci (inhaled/Class W)
Skin contamination dose rate:	8,700-9,170 mrem/mCi/cm^2 (7 mg/cm^2 or 0.007 cm depth in tissue)

Dose rate to basal cells from skin contamination of 9,200 mrad/hr: 1.0mCi/cm^2 (localized dose)

Bone receives approximately 20% of the dose ingested or inhaled for soluble ^{32}P compounds.

Tissue with rapid cellular turnover rates shows higher retention due to concentration of phosphorous in the nucleoproteins.

^{32}P is eliminated from the body primarily via urine.

SHIELDING

¼ thick Plexiglas/acrylic/Lucite/plastic/wood
Do not use lead foil or sheets! Penetrating Bremsstrahlung x-rays will be produced!

Use lead sheets or foil to shield Bremsstrahlung x-rays only after low density Plexiglas/acrylic/Lucite/wood shielding.

SURVEY INSTRUMENTATION

GM survey meter and end window or pancake probe.

Low energy NaI probe is used only to detect Bremsstrahlung x-rays.

Liquid scintillation counter (indirect counting) may be used to detect removable surface contamination of ^{32}P on smears or wipes.

PHOSPHORUS-33
[^{33}P]

PHYSICAL DATA

Beta energy:	0.249 MeV (maximum, 100% abundance) 0.085 MeV (average)
Physical half-life:	25.3 days
Biological half-life:	19 days (40% of intake; 30% rapidly eliminated from body, remaining 30% decays)
Effective half-life:	24.9 days
Specific Activity:	1,000 – 3,000 Ci/millimole
Maximum beta range in air:	89 cm = 35 inches = 3 feet
Maximum range in water/tissue:	0.11 cm = 0.04 inches
Maximum range in Plexiglas:	0.089 cm = 0.035 inches

RADIOLOGICAL DATA

Critical organ (biological destination) (soluble forms): Bone marrow

Critical organs (insoluble forms or non-transportable ^{33}P compounds): Lungs (inhalation) and G.I. tract/lower large intestine (ingestion)

Routes of intake: Ingestion, inhalation, puncture, wound, skin contamination (absorption) Internal exposure and contamination are the primary radiological concerns

Committed Dose Equivalent (CDE): 0.5 mrem/mCi (inhalation)

Skin contamination dose rate: 2,910 mrem/hr/uCi/cm^2 (7mg/cm^2 or 0.007 cm depth in tissue)

Fraction of ^{33}P beta particles transmitted through the dead skin layer is about 14%.

Tissue with rapid cellular turnover rates shows higher retention due to concentration of phosphorus in the nucleoproteins.

^{33}P is eliminated from the body primarily via urine.

Phosphorus metabolism :	30% is rapidly eliminated from the body 40% has a 19-day biological half-life 60% of ^{33}P (ingested) is excreted from the body in first 24 hrs

SHIELDING

Not required; however low density material is recommended, e.g., 3/8 inch thick Plexiglas, acrylic, Lucite, plastic or plywood

SURVEY INSTRUMENTATION

GM survey meter with a pancake probe
Liquid scintillation counting of wipes may be used to detect removable surface contamination.

SULFUR-35
[^{35}S]

PHYSICAL DATA

Beta energy:	167 keV (maximum) 53 keV (average) (100% abundance)
Physical half-life:	87.2 days
Biological half-life:	623 days (unbound ^{35}S)
Effective half-life:	44-77 days (unbound ^{35}S)
Specific activity:	42,400 Ci/gram
Maximum beta range in air:	26.00 cm = 10.2 inches
Maximum beta range in water or tissue:	0.32 mm = 0.015 inches
Maximum beta range in Plexiglas:	0.25 mm = 0.01 inches

Fraction of ^{35}S betas transmitted through the dead layer of skin = 12%

RADIOLOGICAL DATA

Critical organ: Testis
Routes of intake: Ingestion, inhalation, puncture, wound, skin contamination (absorption)
External exposure (deep dose) from weak ^{35}S beta particles is not a radiological concern.
Internal exposure and contamination are the primary radiological concerns.

Committed dose equivalent (CDE):	10.00 mrem/uCi (ingested) 0.352 mrem/uCi (puncture)
Committed effective dose equivalent: (CEDE)	2.6 mrem l/uCi (ingested)* *(Assumes a 90 day biological half-life)
Annual limit of intake (ALI):	10 mCi (ingestion of inorganic compounds) 6 mCi (ingestion of elemental ^{35}S) 8 mCi (ingestion of sulfides or sulfates/LLI) 10 mCi (inhalation of ^{35}S vapors) 20 mCi (inhalation of sulfides or sulfates) 2 mCi (inhalation of elemental ^{35}S)

1.0 ALI = 10 mCi (inhalation ^{35}S vapors) = 5,000 mrem CEDE
1.0 ALI = 8 mCi (ingestion sulfides/sulfates LLI) = 50,000 mrem CDE

Skin contamination dose rate: 1,170 – 1,260 mrem/1.0 uCi/cm^2 (7.0 mg/cm^2 depth)

Beta dose rate for ^{35}S:	14.94 rad/h (contact) in air per 1.0 mCi
	0.20 rad/h (6 inches) in air per 1.0 mCi

SHIELDING

None required (¾ mm Plexiglas shielding optional)

SURVEY INSTRUMENTATION

Can detect using a thin window GM survey meter (pancake), however, probe must be close range, recommend 1 cm distance.

GM survey meter has low efficiency, usually 4 – 6%.

Liquid scintillation counter (wipes, smears) may be used for secondary, **but will not detect non removable contamination!**

IODINE-125
[^{125}I]

PHYSICAL DATA

Gamma Energies:	35.5 keV (7% abundance/93% internally converted gamma)
(No betas emitted)	27.0 keV (113%, x-ray)
	27-32 keV (14%, x-ray)
	31.0 keV (26%, x-ray)

Specific Gamma Ray Constant: 0.27 to 0.70 mR/hr per mCi at 1 meter
(Current literature indicates 0.27 mR/hr per mCi at 1 meter)

Physical Half-Life:	60.1 days
Biological Half-Life:	120-138 days (unbound iodine)-thyroid elimination
Effective Half-Life:	42 days (unbound iodine)-thyroid gland
Specific Activity:	17,400 Ci/gm (theoretical/carrier free)
Intrinsic Specific Activity:	22.0 Ci/millimole

RADIOLOGICAL DATA

Critical Organ (Biological Destination): Thyroid
Routes of Intake: Ingestion, inhalation (most probable), puncture, wound, skin contamination (absorption)

External and internal exposure and contamination concerns exits in use of ^{125}I

Committed Dose Equivalent (CDE):	814 mrem/mCi (thyroid/inhalation/class "D")
	1,185 mrem/mCi (thyroid/ingestion/NaI form)
	910 mrem/mCi (thyroid/inhalation)
	1,258 mrem/mCi (any organ/puncture/adult)

Committed Effective Dose Equivalent (CEDE): 24 mrem/mCi (whole body/inhalation)

SHIELDING

Lead foil or sheets (1/32 to 1/16 inch thick): 0.152 mm lead foil

SURVEY INSTRUMENTATION

Survey meter equipped with a low energy NaI scintillation probe is necessary.
Survey meter equipped with GM pancakes or end window GM probes are inefficient. These probes are not useful for contamination monitoring; they are only about 0.1% efficient.

IODINE-131
[^{131}I]

PHYSICAL DATA

Gamma Energies:	364 keV (81% abundance)
	637 keV (7% abundance)
	284 keV (6% abundance)
Beta Energies:	606 keV (89% abundance)
	334 keV (7% abundance)
	248 keV (2% abundance)

Specific Gamma Ray Constant: 0.28 mR/hr per mCi at 1 meter

Physical Half-Life:	8.04 days
Biological Half-Life:	120-138 days (unbound iodine)-thyroid elimination
Effective Half-Life:	7.6 days (unbound iodine)-thyroid gland
Specific Activity:	124,000 Ci/g

RADIOLOGICAL DATA

Critical Organ (Biological Destination): Thyroid
Routes of Intake: Ingestion, inhalation (most probable), puncture, wound, skin contamination (absorption)

External and internal exposure and contamination concerns exits in use of ^{131}I

Committed Dose Equivalent (CDE):	1.08 rem/μCi (thyroid/inhalation)
	1.76 rem/μCi (thyroid/ingestion)

SHIELDING

Lead: Half Value Layer = 3 mm Tenth Value Layer = 11 mm

SURVEY INSTRUMENTATION

Survey meter equipped with GM pancakes or end window GM probes.
Liquid Scintillation Counter or Gamma Counter for wipe tests.

FLUORINE-18
[^{18}F]

PHYSICAL DATA

Radiation: Gamma: 511 keV (194% abundance; positron annihilation radiation)
Betas: 634 keV (97% abundance) [Positron]
Gamma Constant: 1.879E-04 mSv/hr per MBq at 1 meter1 [6.952E-4 mrem/hr per uCi at 1 m]
Half-Life [T½]: Physical T½: 1.83 hours
Biological T½: ~ 6 hours
Effective T½: ~ 1.4 hours
Specific Activity: 9.51E7 Ci/g [3.52E18 Bq/g]

RADIOLOGICAL DATA

Radiotoxicity: Ingested: 2.9E-10 Sv/Bq [1.1 mrem/uCi] stomach wall
3.31E-11 Sv/Bq [0.12 mrem/uCi] CEDE
Inhaled: 1.4E-10 Sv/Bq [0.52 mrem/uCi] Lung
2.3E-11 Sv/Bq [0.084 mrem/uCi] CEDE
Critical Organ: Lung (inhalation); stomach wall (ingestion)
Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard: External & Internal Exposure; Contamination

SHIELDING

Gamma:	Half Value Layer (HVL)	Tenth Value Layer (TVL)
Lead [Pb]	6 mm	17 mm

Beta Shielding: 1.7 mm plastic
- The accessible dose rate should be background but must be < 2 mR/hr

DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{18}F

SURVEY INSTRUMENTATION

Survey meter equipped with GM pancakes or end window GM probes.
Liquid Scintillation Counter or Gamma Counter for wipe tests. However, wipes must be run soon after sample collection due to short half-life.

APPENDIX VIII

ACCEPTABLE SURFACE CONTAMINATION LEVELS

APPENDIX VIII
ACCEPTABLE SURFACE CONTAMINATION LEVELS*

NUCLIDE[1]	AVERAGE [2,3,6]	MAXIMUM [2,4,6]	REMOVABLE [2,3,5,6]
U-nat, U-235, U-238, and associated decay products except Ra-226, Th-230, Ac-227, and Pa-231	5,000 dpm alpha/100 cm^2	15,000 dpm alpha/100 cm^2	1,000 dpm alpha/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-125, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm beta, gamma/100 cm^2	15,000 beta, gamma/100 cm^2	1,000 dpm beta, gamma/100 cm^2

[1] Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established for alpha and beta/gamma emitting nuclides should apply independently.

[2] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background efficiency, and geometric factors associated with the instrumentation.

[3] Measurements of average contamination level should not be averaged over more than one square meter. For objects of less surface area, the average should be derived for each object.

[4] The maximum contamination level applies to an area of not more than 100 cm^2.

[5] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally, and the entire surface should be wiped.

[6] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

* Adapted from RH-1213 Arkansas *Rules and Regulations for Control of Sources of Ionizing Radiation.*