

A stylized radiation symbol is centered on the page. It consists of three magenta-colored blades, each shaped like a quarter-circle with a pointed tip, arranged in a three-bladed pattern. The blades are set against a solid yellow background. A white rectangular box with a thin blue border is positioned on the right side of the page, partially overlapping the rightmost blade of the radiation symbol. The title text is contained within this white box.

Radiation Safety Manual

*Environmental Health and
Safety*

Introduction

The objectives of the University of Memphis Radiation Safety Program are to assist in fulfilling the University's commitment to provide a safe and healthy environment for employment and learning and to always establish and promote safe practices. Protection of employees, students, the public, and university property and operations are paramount and every attempt will be made to ensure that our facilities are as free as possible from recognized radiation hazards.

The Tennessee Division of Radiological Health has issued a Specific Broad Scope License to University of Memphis. This license authorizes and tightly regulates the responsible use of radionuclides on our campus.

The purpose of University of Memphis's Radiation Safety Manual is to assist faculty, staff, and students in complying with the regulations of the Tennessee Division of Radiological Health and the University of Memphis Radiation Safety Committee. This manual is not intended to be an exhaustive or fully comprehensive reference, but rather a guide to enable qualified personnel safe and efficient use of radionuclides and ancillary staff protection from undesirable exposure to the effects of radionuclide use. Further information associated with the use of radioactive materials on this campus can be obtained by contacting the University of Memphis Radiation Safety Officer. Copies of this manual and regulations cited herein are available for viewing during regular business hours in the office of the Radiation Safety Officer and via the EHS web site at <https://www.memphis.edu/ehs/labsafety/radsafety.php>.

FOR Emergency Assistance

In case of an emergency or accident situation:

Notify:

Radiation Safety Officer at 901-678-4672

or

Environmental Health & Safety at 901-678-5700

Nights, Weekends or Holidays:

Notify

University Police

901-678-4357

AND

Radiation Safety Officer

864-710-2933

For routine information contact the Radiation Safety Officer

at ehs@memphis.edu.

Contents

<i>Introduction</i>	<i>1</i>
<i>Chapter 1 Radiation Safety Committee</i>	<i>5</i>
1.1 Purpose	5
1.2 Organization	5
1.3 Responsibilities	5
<i>Chapter 2 Radiation Safety Officer Duties and Responsibilities.....</i>	<i>6</i>
<i>Chapter 3- Licensing and Registration Regulations</i>	<i>7</i>
3.1 Federal Regulations	7
3.2 State Regulations.....	8
3.3 University of Memphis Campus Regulations	8
3.4 Posting of Notices	8
<i>Chapter 4- Approved Users and Their Responsibilities</i>	<i>8</i>
4.1 Responsible User.....	8
4.2 Authorized User	9
4.3 Responsibilities of Users.....	10
<i>Chapter 5- Procurement and Use of Radioactive Materials</i>	<i>11</i>
5.1 Radiation-Producing Devices	11
5.2 Industrial Radiography	11
5.3 Procedure for Obtaining Radioactive Material.....	11
5.4 Procedure for Receiving Radioactive Materials	12
5.5 Use of Radioactive Materials for Experimental Purposes.....	12
5.6 Transportation of Radioactive Materials.....	13
5.7 Inventories	13
<i>Chapter 6- Radiation Dose and Monitoring.....</i>	<i>14</i>
6.1 Radiation Dose Limits	14
6.1.1 ALARA	14
6.1.2 Occupational Dose Limits.....	14
6.1.3 Minors Working with Radioactive Materials	15
6.1.4 Exposure Limits for the General Public	15
6.1.5 Exposure Limits to an Embryo/Fetus	15

6.2 Personnel Monitoring	16
6.3 Bioassays	16
Chapter 7- Radiation Controls	17
7.1 Engineering Controls.....	17
7.2 Work Practices	17
7.3 Other Methods.....	17
7.4 Signs and Labels.....	18
7.4.1 Radiation Producing Devices	18
7.4.2 Radiation Area	18
7.4.3 High Radiation Area.....	18
7.4.3 Airborne Radioactivity Area.....	18
7.4.4 Other Areas.....	19
7.4.5 Containers.....	19
7.6 Vacating Laboratory Spaces	19
Chapter 8 Surveys and Leak Tests.....	20
8.1 Area Surveys	20
8.2 Removable Contamination Surveys	20
8.4 Leak Tests.....	21
8.4 Survey Instrument Calibration	21
Chapter 9 Radioactive Waste	21
Chapter 10 Emergency Procedures and Security	23
10.1 Minor Spills or Contamination of Surfaces.....	23
10.2 Major Spills Involving Radiation Hazard to Personnel.....	23
10.3 Accidents Involving the Release of Airborne Radioactive Materials.....	24
10.4 Accidents Involving Possible Overexposure of Personnel.....	24
10.5 Follow-up Procedures for All Incidents.....	24
10.6 Security	25

Chapter 1 Radiation Safety Committee

1.1 Purpose

The Tennessee Division of Radiological Health within the Tennessee Department of Environment and Conservation regulations require the establishment of a Radiation Safety Committee (RSC). The purpose of the RSC is to promote the best practice in safe handling and use of radiation sources. The RSC is also established to assure compliance with State regulations and the conditions set forth by the license. Any individual or action, which jeopardizes the license, endangers the permission of all researchers to utilize radioactive materials at University of Memphis.

1.2 Organization

The Radiation Safety Committee, which meets at least annually and as necessary to conduct the business of the radiation safety program, is comprised of the Radiation Safety Officer, Committee Chair (an appropriate representative appointed by the Division of Research and Innovation), one (1) licensed user, one (1) physicist with knowledge of radiation physics and two (2) faculty members trained and experienced in the safe use of radioactive materials.

1.3 Responsibilities

This Committee is responsible for establishing procedures and policies for the authorized procurement, protection, use, and disposal of radioactive materials and for the safety and protection of all personnel, students and visitors, on the University of Memphis campus. The Committee shall:

1. Provide technical and administrative guidance and aid in the interpretation of various regulations governing the use of radioactive materials.
2. Review and act upon all new, renewal, and amended applications for possession and use of radioactive materials.
3. Determine the adequacy of training and experience of persons requesting permission to use or supervise the use of radioactive materials.
4. Determine the suitability of space, facilities, or equipment designated for use or storage of radioactive materials.
5. Receive and review periodic reports from the RSO on monitoring, contamination, and personnel exposure.
6. Meet, at the call of the chair of the Radiation Safety Committee or designated representative, to review alleged infractions of safety rules and regulations, incidents, and emergencies concerning any radiation program or project.
7. Provide recommendations to the RSO for items 3-6 above.

Chapter 2 Radiation Safety Officer Duties and Responsibilities

Radiation Safety Officer derives authority from the Division of Finance and Administration with support from the Division of Research and Innovation. The RSO's duties and responsibilities include ensuring radiological safety and compliance with Tennessee Division of Radiological Health and Department of Transportation regulations and the conditions of the University license. The RSO's duties and responsibilities include the following:

1. Ensure that the radioactive material possessed by University of Memphis is limited to the types and quantities of material listed on the license.
2. Oversee all activities involving radioactive material, including monitoring and surveys of all areas in which radioactive material is used and stored.
3. Provide necessary information on all aspects of radiation protection to personnel at all levels of responsibility.
4. Oversee proper delivery, receipt, and radiation surveys of all shipments of radioactive material arriving at the University, as well as proper packaging and labeling of all radioactive material being shipped from the University.
5. Maintain an active inventory of all radioisotopes housed at University of Memphis and records of their disposal.
6. Distribute and process personnel radiation monitoring equipment, determine the need for and evaluate bioassays, monitor personnel radiation exposure and bioassay records for trends and high exposures, notify individuals and their supervisors of radiation exposures approaching the limits, and recommend appropriate remedial action.
7. Coordinate or conduct training programs and otherwise instruct personnel in the proper procedures for handling radioactive material prior to use, at periodic intervals (annual refresher training), and as required by changes in procedures, equipment, regulations, etc. Ensure that all ancillary employees and emergency personnel whose assigned duties may involve exposure to radioactive materials in the course of their employment are trained in Radiation Safety.
8. Supervise and coordinate the radioactive waste disposal program, including effluent monitoring and recordkeeping on waste storage and disposal records.
9. Oversee and manage the storage of radioactive material not in current use, including waste.
10. Perform or arrange for leak tests on all sealed sources and for calibration of radiation survey instruments.
11. Immediately terminate any unsafe condition or activity that is found to be a threat to public health and safety or property.
12. Maintain other records not specifically designated above, including records of receipts, transfers, and surveys as required by Tennessee Division of Radiological Health Rules and Regulations.

13. Attend periodic meetings of the Radiation Safety Committee and provide reports to the committee.
14. Ensure that the results of audits, identification of deficiencies, and recommendations for change are documented (and maintained for at least 3 years) and provided to the Radiation Safety Committee and the Executive Vice President for Research and Innovation for review; ensure that prompt action is taken to correct deficiencies.
15. Ensure that the audit results and corrective actions are made available to all personnel who use licensed material.
16. Ensure that all incidents, accidents, and personnel exposure to radiation as defined by the TDEC Rules and Regulations are investigated and reported to the Tennessee Division of Radiological Health and other appropriate authorities, if required, within the required time limits.
17. Maintain understanding of and up-to-date copies of regulations, the license and revised license procedures, and ensure that the license is amended whenever there are changes in licensed activities or responsible individuals.

Chapter 3- Licensing and Registration Regulations

3.1 Federal Regulations

There are several areas in which the Federal Government retains regulatory powers in agreement states such as Tennessee.

1. The receipt, possession, use or transfer of by-product, source or special nuclear materials in quantities sufficient to form a critical mass.
2. The construction and operation of any production or utilization facility.
3. The export from or import into the United States of by-product, sources, special nuclear material, or electronic devices.
4. Any agency of the Federal Government.

In all other cases the Tennessee Division of Radiological Health, Division of Radiation Control and Emergency Management is given the power to license and regulate the receipt, possession, use and transfer of sources of ionizing radiation.

3.2 State Regulations

Because Tennessee is an agreement state, the Tennessee Division of Radiological Health has the authority to license or register radiation sources and to enforce the regulations governing the activities of a licensee or registrant. University of Memphis has been issued a specific broad scope license.

Within the conditions imposed by the Tennessee Division of Radiological Health through the Rules and Regulations, the licensee (University of Memphis) is allowed to state what procedures it will follow in the safe use of radioactive materials. Our radioactive materials license therefore contains both state requirements and self-imposed operating procedures that have been approved by the state. When University of Memphis is inspected, we are examined for compliance with both the Rules and the conditions of our license.

Copies of the Standards for Protection Against Radiation can be obtained by visiting Environmental Health & Safety (316A Scates Hall). A copy of these regulations may also be obtained by visiting: <https://publications.tnsosfiles.com/rules/0400/0400-20/0400-20.htm>

Copies of the current radioactive materials license with all the amendments approved can be found in the Environmental Health & Safety Office.

3.3 University of Memphis Campus Regulations

No person may use or transfer radioactive materials into or on the campus of University of Memphis without prior approval by the Radiation Safety Committee.

All statements related to procurement, use and disposal of radioactive materials appearing in this booklet will be considered as the regulations for University of Memphis, as they reflect the Rules and Regulations, the University of Memphis license, and the policy decisions of the Radiation Safety Committee. This manual is not intended to be a comprehensive reference. If further information is needed, consult the Tennessee Division of Radiological Health, Rules and Regulations for Control for Sources of Ionizing Radiation, the University of Memphis license, or the Radiation Safety Officer.

3.4 Posting of Notices

The Tennessee Division of Radiological Health has adopted regulations with standards to protect you from hazards associated with radioactive materials. This requires that University of Memphis post in a conspicuous place for all employees working in any portion of a restricted area a copy of "Notice to Employees" "Standards for Protection Against Radiation".

Chapter 4- Approved Users and Their Responsibilities

4.1 Responsible User

Responsible Users are those persons who are permitted by the Radiation Safety Committee to purchase, store and use radioactive materials under the University of Memphis license (See Appendix II for Training and Experience Requirements). The Responsible Users are responsible for the safe use of radiation sources by individuals under their control. The Responsible user is responsible for:

1. Compliance with the University of Memphis rules and regulations for radiation safety and the State "Standards for Protection Against Radiation".
<https://publications.tnsosfiles.com/rules/0400/0400-20/0400-20.htm>
2. Obtaining approval of the Radiation Safety Committee prior to obtaining radioactive materials or carrying out a research protocol involving radioactive materials.
3. Ensuring that all authorized users have successfully completed an approved training program. All Responsible users must have completed the course or show documentation of equivalent knowledge or experience.
4. Developing protocols for the research/experiment, to ensure that appropriate safety precautions are taken.
5. Notifying the RSO prior to any personnel changes, including addition or termination of employees/students, or changes in operational procedures, new techniques, or changes of areas where radioactive materials may be used or stored.
6. Directing of personnel under their control to comply with all recommendations to wear pocket dosimeters and finger badges, to survey their hands and clothing, to submit to bioassay, etc. which are designed to control and to reduce their total exposure.
7. Maintenance of required records of receipt, use, storage, and disposal of radioisotopes.
8. Segregation, containment, labeling, and proper disposal of all radioactive waste in accordance with guidelines.
9. Promptly notifying the Radiation Safety Officer of any accidents or incidents.
10. Ensuring that the personnel under their control discharge their individual responsibilities as listed in Section 4.4.

NOTE: Cleanup of contaminated equipment or areas is the responsibility of the Responsible user and the persons creating the contamination. It may not be assigned or delegated to staff outside the laboratory, such as custodial or maintenance workers.

4.2 Authorized User

An authorized user is a person who has been added to the Responsible User's Authorization and has completed the appropriate training. The authorized user is responsible to the Responsible User for all actions listed below for radioactive material. This user may work with isotopes or equipment without immediate supervision and may assume limited responsibilities as defined by the Responsible User.

4.3 Responsibilities of Users

One of the basic tenets of safety is that all individuals must take responsibility for their own safety and ensure that any actions taken do not constitute a hazard to others or to the environment. Each person at University of Memphis who has any contact with sources of radioactive materials has the following responsibilities:

1. Keep exposure to radiation As Low As Reasonably Achievable (ALARA).
2. Expose liquid or other sources that will disperse in the atmosphere under fume hoods.
3. Wear the recommended radiation monitoring devices for personnel, such as pocket dosimeters and finger badges.
4. Use all recommended protective measures such as protective clothing, remote-handling tools. Mouth pipetting is prohibited.
5. DO NOT smoke, eat, drink, chew gum or tobacco, or apply cosmetics or contact lenses in an area where radioactive materials are used or stored. DO NOT store or prepare food or drink in any area that has been used for radioactive materials, e.g., refrigerators, cabinets, glassware. If food or empty food packaging is found in the normal trash, this is interpreted as "evidence of consumption" by regulators.
6. Maintain good housekeeping and clean working habits. Work surfaces must be covered with a plastic backed absorbent paper. Where practical, an impervious tray or pan should be used under the paper to ensure containment of spills. Working areas must be clearly delimited.
7. Survey work areas at least weekly when less than 200 uCi are used; otherwise, survey daily at the end of each laboratory or work period.
8. Label radiation equipment and segregate radioactive waste and equipment to avoid cross contamination.
9. Report immediately to the Responsible User and RSO the details of a spill or other accidents involving radioactivity.
10. Maintain a log of all meter and wipe surveys conducted by the user. (See Appendix V for Logbook Guidelines).
11. Carry out decontamination procedures when necessary and take the necessary steps to prevent the spread of contamination to other areas.
12. Clean hands when leaving the laboratory.

When using radioisotopes other than low energy beta emitters, the following extra precautions are required:

13. Place all sources behind suitable shielding.
14. Survey hands, feet, clothing and personal materials at the end of each laboratory or work period.
15. Monitor radiation with a survey meter when radioisotopes are being used.

16. Annual retraining

Chapter 5- Procurement and Use of Radioactive Materials

5.1 Radiation-Producing Devices

No person or group shall purchase or otherwise possess on University property any radiation producing device without the written consent of the RSO or RSC unless such device is specifically exempted from registration by the Tennessee Division of Radiological Health (DRH). Non-exempt radiation producing devices shall be registered with DRH in a timely manner and shall be inspected annually or at other intervals as directed by regulations and the RSO.

All safety devices, such as interlocks, shutters, and warning lights, on radiation producing devices shall be tested by the using department at intervals not to exceed three (3) months; records of these tests shall be maintained for inspection by DRH and the RSO.

Operation of radiation producing devices shall be limited to personnel with training and experience considered acceptable by the RSO. Personnel using radiation producing devices on humans shall hold an acceptable certification by the State Board of Medical Examiners or other accreditation body acceptable to DRH and the RSO. Where such devices are intended for use in research on human subjects, an Institutional Review Board approved protocol shall be obtained prior to, and maintained throughout the period of, such use.

5.2 Industrial Radiography

Departments intending to engage in industrial radiography shall contact the RSO well in advance of such operations and shall follow regulations found in Chapter 0400-20-08, Radiation Safety Requirements for Industrial Radiography Operations, as found in "State Regulations for Protection Against Radiation." Those planning industrial radiography operations should be prepared financially to support these additional regulatory requirements.

5.3 Procedure for Obtaining Radioactive Material

Radioactive materials may be obtained by any department or unit of the University subject to the conditions listed below:

1. The individual requesting acquisition of radioactive materials on behalf of the University, or for use on a UofM campus or any other area controlled by the UofM, shall be approved by the Tennessee Division of Radiological Health and listed on the applicable Tennessee radioactive material license. That individual, the RU, will be the person held accountable for the material until it is transferred to another RU who can legally accept it or until it is properly disposed of. All transfers shall be reported to the RSO.

2. Prior approval of the Radiation Safety Officer shall be obtained before acquiring such radioactive materials.

5.4 Procedure for Receiving Radioactive Materials

Radioactive materials are to be shipped to and received in a timely manner by a qualified individual in the ordering department or unit. Within three (3) hours of receipt, each package shall be examined as follows:

1. The package shall not show visible signs of leakage or physical damage which could release radioactive contaminants.
2. The surface of a package containing gamma or neutron emitting radioisotopes shall be monitored for radiation, and levels more than 200 millirem/hour must be reported to the RSO.
3. The surface of a package containing alpha or beta emitters shall be checked for removable contamination by use of a wipe test. Removable contamination more than 0.01 microcurie (22,200 dpm) per 100 square centimeters must be reported to the RSO.
4. Packages not failing the above criteria may be opened, the contents verified against the packing slip and original order, and inner container examined for integrity.
5. If a received package fails any of the above criteria, steps shall be taken immediately to prevent the spread of contamination and to remediate existing problems.

Where surface contamination or external radiation levels exceed the above limits, the RSO or a designated representative shall notify the final delivery carrier and the Tennessee Division of Radiological Health in accordance with 0400-20-05-.115.

Prior to disposal, empty packing materials shall be surveyed. Materials found to be contaminated must be handled as radioactive waste; non-contaminated packing may be disposed of as normal solid waste after radiation labels and markings are obliterated.

Departments receiving radioactive materials shall maintain complete records on all shipments received, including survey results, with copies to the RSO.

5.5 Use of Radioactive Materials for Experimental Purposes

Laboratory procedures involving radioisotopes must be done, or directly supervised by, an RU. Experiments involving radioisotopes in quantities greater than two (2) times those specified in Schedule RHS 8-31 require prior approval of the Radiation Safety Committee for each new experiment. However, an approved procedure may be repeated without additional approval provided the amount of

radioactive material is not increased more than 25% above the authorized amount. In the case of continuous or repeated use of an isotope for an approved procedure, the quantity used weekly will be subject to the above limits provided the total quantity involved in the experiment at one time is not more than 25% above the authorized amount and the total quantity possessed (including stored waste) does not exceed the licensed limit. Experiments involving quantities less than those noted above may be approved by the RSO.

Requests for approval of experimental procedures should be made in writing to the RSO. Requests should clearly state:

1. The individual who will direct the experiment and be responsible for the radioactive material involved (the RU).
2. The names of all individuals who will work with, or be in the presence of, the material.
3. The qualifications of all individuals involved, including training and experience in handling radioisotopes.
4. The isotopes and quantities involved.
5. A brief description of the experiment with an analysis of the radiation hazards involved, including external exposure, absorption, ingestion, and inhalation.
6. A description of the facility, including an annotated floor plan, where the experiment will be performed; and
7. A description of precautions that will be taken to ensure that radiation exposures to individuals are kept as low as reasonably achievable.

5.6 Transportation of Radioactive Materials

Transportation of radioactive material by UofM personnel shall be done in accordance with state and federal regulations, including packing, manifesting, placarding of vehicles, and associated items addressed in Title 49 of the Code of Federal Regulations.

5.7 Inventories

An inventory of all radioisotopes shall be kept by the radiation safety officer. Inventories within laboratories shall be kept by the responsible user and supplied to the Radiation Safety Officer upon request.

Chapter 6- Radiation Dose and Monitoring

6.1 Radiation Dose Limits

6.1.1 ALARA

ALARA is an acronym meaning As Low As Reasonably Achievable. It is a requirement in the law for all facilities possessing radioactive materials licenses to have a formal ALARA program. The radiation protection standards set forth in this manual are used to control radiation exposure to all personnel occupationally exposed to radiation. It is the policy of University of Memphis to keep this exposure as low as reasonably achievable (ALARA).

6.1.2 Occupational Dose Limits

Occupational dose limits to individual adults shall be in accordance with RH-200 of the Tennessee Division of Radiological Health, Rules and Regulations. No individual may receive in one calendar year, except for planned special exposures, a total occupational exposure in excess of the following:

Total Effective Dose	5 rems (0.05 Sv), or
Sum of deep-dose equivalent and committed dose equivalent to any individual organ or tissue other than the lens of the eye	50 rems (0.5 Sv)
Lens of the eye (lens dose)	15 rems (0.15Sv) and
Skin & extremities	Shallow dose equiv. of 50 rems (0.50Sv)

DE – Dose Equivalent is 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).

CDE – Committed Dose Equivalent ($H_{T,50}$) is 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.

EDE – Effective Dose Equivalent (H_E) is 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 ($H_E = \sum w_T H_T$).

CEDE – Committed Effective Dose Equivalent ($H_{E,50}$) is 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 ($H_{E,50} = \sum w_T H_{T,50}$).

DDE – Deep Dose Equivalent (H_d), (which applies to external whole-body exposure) is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm²).

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

SDE – Shallow-dose Equivalent (H_s), (which applies to the external exposure of the skin or an extremity) is the dose equivalent at a tissue depth of 0.007 centimeter (7mg/cm²), averaged over an area of one (1) square centimeter.

LDE – Lens of Eye Dose Equivalent. 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/cm²).

6.1.3 Minors Working with Radioactive Materials

The annual occupational dose limits to minors, (individuals under the age of 18) must be limited to ten percent (10%) of the annual dose limits specified for adult workers. For these workers/students, safety training must be completed prior to work with radioactive materials as with other occupational workers and students.

6.1.4 Exposure Limits for the General Public

Any person who is not regularly employed or authorized in using radioactive materials must not receive a radiation dose in excess of either:

- 0.1 rem (1 mSv) in any one year.
- 0.002 rem (0.02 mSv) in any one hour.

6.1.5 Exposure Limits to an Embryo/Fetus

Occupational radiation dose to the embryo/fetus shall not exceed 0.500 rem during the entire pregnancy with no more than 0.050 rem permitted in any one month. The dose to an embryo/fetus shall be taken as the sum of the deep-dose equivalent to the declared pregnant woman and the dose to the embryo/fetus due to radionuclides in the embryo/fetus and in the declared pregnant woman. To assure

early implementation of dose monitoring for the fetus, it is the responsibility of the pregnant worker to advise the RSO of the pregnancy as soon as possible.

6.2 Personnel Monitoring

Personnel monitoring devices (dosimeters) shall be worn by individuals likely to receive a dose in excess of 10 percent of applicable limits as noted in the previous table, or who enter a high or very high radiation area. Minors and declared pregnant women likely to receive a dose in excess of 5 percent of these limits shall be supplied with dosimeters.

Body badges and/or finger rings are issued by, and returned to, the Radiation Safety Officer on a periodic basis (generally monthly). Rings are normally required only for those whose hands are placed near radiation sources. When entering areas where indeterminate radiation levels are suspected, individuals may also be required to wear a temporary, direct reading dosimeter issued by the RSO.

Responsible Users must notify the Radiation Safety Office when individuals under their supervision need monitoring. Dosimetry service is continued until termination is requested by the RU or department chair.

When not in use, personnel dosimeters should be stored in areas away from radiation sources, excessive heat, and moisture. A personnel dosimeter should never be deliberately exposed to radiation or worn during non-occupational radiation exposure (e.g., medical or dental x-rays).

6.3 Bioassays

Bioassays may be required for personnel handling or using unsealed radioactive sources, and are required for adults likely to receive an annual intake in excess of 10 percent of the applicable annual intake limits found in Table 1, Columns 1 and 2, of Schedule RHS 8-30.

Minors and declared pregnant women likely to receive an annual committed effective dose equivalent in excess of 10 percent of any limits in Tennessee Rules 0400-20-05-.55 and 0400-20-05-.56 may be required to submit to bioassays.

Individuals working with ten (10) or more millicuries of tritium, carbon-14, phosphorus-32, sulfur-35, and other beta-emitting isotopes per month should submit urine samples for counting within 24 to 48 hours after a single large procedure, following a significant spill, at monthly intervals for continuing operations, or upon request of the RSO. Those routinely working with one (1) or more millicuries of tritiated nucleic acids and precursors (thymidine, guanosine, adenosine, cytidine, and phosphorylated derivatives) should submit a urine sample every other month.

Individuals using more than one (1) millicurie of radioiodine per month in unsealed form should submit to a thyroid count monthly, or at other intervals when deemed appropriate for the particular isotope

and procedure. Thyroid counts should be performed within seventy-two (72) hours, but no sooner than six (6) hours, after working with unsealed sources of radioiodine.

Occupational radiation exposure records, including bioassay results, shall be maintained in the Radiation Safety Office.

Chapter 7- Radiation Controls

7.1 Engineering Controls

Fume hoods are essential to minimizing airborne contamination; however, the use of fume hoods shall be limited to units which meet current safety acceptance criteria as adopted by the University Environmental Health and Safety Office. Proper operation shall be documented on inspection stickers affixed to each fume hood. All newly constructed fume hoods shall include a stack extending at least seven (7) feet above the roof and shall have no weather cap or other obstruction which would interfere with the vertical discharge of contaminants. Where indicated due to risks to personnel or the environment, fume hoods should be equipped with an appropriate filter and manometer. In situations such as iodination which could release radioisotopes more than limits found in Schedule RHS 8-30, Table 2, without a filter, iodination cabinets or other secondary means of containment shall be used to assure that stack emissions are below said limits. Biological safety cabinets are generally unsuitable for use with volatile radioactive materials.

7.2 Work Practices

Where the potential exists for the release of volatile materials or the creation of aerosols, mists, fumes, dusts, etc., containing radioisotopes, work shall be performed in a qualified fume hood, or within other apparatus capable of isolating the material. For iodination, work practices might also include maintaining iodination solutions at a pH of 9 or greater, using non-oxidative processes, when possible, etc. Where tritium labeled sodium borohydride is used, care should be taken to perform all work, including unpacking, in a suitable fume hood, covering containers tightly when not in a fume hood, and acidifying wastes. Where S-35 labeled amino acid solutions are used, care should be taken to absorb or exhaust volatile radioactive compounds released during radiolytic decay - such compounds may contaminate entire incubators and other equipment.

7.3 Other Methods

When engineering and process control methods are not practicable to reduce levels below those which define an airborne radioactivity area as found in Tennessee Rule 0400-2-5-.32, one or more of the following methods shall be used to maintain total effective dose as low as reasonably achievable:

control of access, limitation of exposure time, use of respiratory protection, or other controls. Respirators shall be selected and used in accordance with a written respiratory protection program, 29CFR1910.134, and Tennessee Rules 0400-20-05-.91, 0400-20-05-.92, 0400-20-05.93, and 0400-20-05-.94.

7.4 Signs and Labels

7.4.1 Radiation Producing Devices

All x-ray machines and related devices capable of generating ionizing radiation shall have affixed to the control panel near the power switch a readily visible label stating:

CAUTION (or DANGER) - RADIATION

THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED

Analytical x-ray machines shall also have a warning label affixed on or near the tube head stating:

CAUTION (or DANGER) - HIGH INTENSITY X-RAY BEAM

7.4.2 Radiation Area

Each room or area accessible to personnel in which there exists radiation levels such that a major portion of the body could receive a dose in excess of 5 millirems in 1 hour, or 100 millirems in any 5 consecutive days, shall be conspicuously posted with a sign or signs displaying the radiation symbol and the words:

CAUTION (or DANGER) - RADIATION AREA

7.4.3 High Radiation Area

Each room or area accessible to personnel in which there exists radiation levels such that a major portion of the body could receive a dose in excess of 100 millirems in any one hour, shall be conspicuously posted with a sign or signs displaying the radiation symbol and the words:

CAUTION (or DANGER) - HIGH RADIATION AREA

7.4.3 Airborne Radioactivity Area

Any room, enclosure, or area in which airborne radioisotopes exist in concentrations in excess of amounts noted in Schedule RHS 8-30, Table 1, Column 3, or any such area in which concentrations could cause an intake of 0.6 percent of that noted in RHS 8-30, Table 1, Columns 2 or 3, in any one week by unprotected personnel, shall be conspicuously posted with a sign or signs displaying the radiation symbol and the words:

CAUTION (or DANGER) - AIRBORNE RADIOACTIVITY AREA

7.4.4 Other Areas

Each area or room where radioactive materials are used or stored in amounts exceeding 10 times those noted in Schedule RHS 8-31 shall be conspicuously posted with a sign or signs displaying the radiation symbol and the words:

CAUTION (or DANGER) - RADIOACTIVE MATERIAL

7.4.5 Containers

Each container of licensed material shall bear a durable, clearly visible label identifying the contents, displaying the radiation symbol, and the words:

CAUTION (or DANGER) - RADIOACTIVE MATERIAL

No such label shall be required for containers holding licensed materials in quantities less than applicable quantities listed in Schedule RHS 8-31, or in concentrations less than those in Schedule RHS 8-30, Table 1, Column 3.

In addition to other posting requirements, copies of "Notice to Employees" (RHS 8-3) shall be posted in sufficient numbers to allow employees to observe a copy on the way to or from an area where radioisotopes or radiation producing devices are used or stored.

7.6 Vacating Laboratory Spaces

Prior to the closing of a laboratory or other area where radioisotopes have been used or stored, departments shall develop procedures for the decommissioning of such areas. These procedures shall provide for:

- 1) Decontamination to levels suitable for unrestricted areas, or provisions for continued monitoring and security of a restricted area;
- 2) Surveys documenting contamination levels;
- 3) Transferring records of receipt and disposal, periodic surveys, etc., to a responsible person within the department to assure continued integrity of documentation;
- 4) Disposal of all radioisotopes, or their transfer to another RU;
- 5) Timely notification of closing to the RSO.

It shall be the responsibility of the department chair or director to assure that the decommissioning process is fully implemented.

Where personnel leave the University or transfer to another lab, the department chair or director shall assure that all radioactive materials under supervision of such personnel are disposed of, transferred to another lab authorized to possess such materials, or removed to storage under supervision of an individual approved by the RSO.

Chapter 8 Surveys and Leak Tests

Each RU, or Department Chair in the absence of an RU, shall make or cause to be made periodic surveys of each laboratory or other area where radioisotopes are used or stored. Surveys shall be made using methods and instruments capable of detecting the radioisotopes used or stored in the survey area. Accurate records, including floor plans of rooms with survey locations marked, survey results, and action taken to remove contamination shall be maintained by the affected departments.

8.1 Area Surveys

Areas routinely using unsealed gamma emitters, and beta and alpha emitters capable of being detected by survey meters, shall be surveyed at least weekly, but more often when any procedure is likely to produce significant contamination. Where removable contamination is likely, area surveys should complement wipe tests by locating areas suitable for wipe testing. It is suggested that areas with sealed gamma or neutron sources be surveyed monthly but may be surveyed less often if items are in storage and no changes are made in shielding, location, or other parameters which would affect exposure of personnel.

8.2 Removable Contamination Surveys

Wipe tests shall be executed at least weekly in areas where non-sealed sources are routinely used, and more often when special procedures are used. Several locations subject to contamination should be wiped with filter paper or other suitable material over an area of approximately 100 square centimeters and the swipe counted appropriately (tritium and other very weak emitters will require the use of a scintillation counter). Counting results should be referenced to locations on the floor plan.

While removal of any surface contamination is prudent, removable contamination in restricted areas **shall not** exceed the following levels for any 100 square centimeter area:

Radiation Emitted	Maximum Contamination
Alpha	220 dpm
Beta or Gamma	2,200 dpm
Low Energy Beta (less than 0.2 MeV)	22,200 dpm

Removable contamination per 100 square centimeters **shall not** exceed the following levels in unrestricted areas and on skin:

Radiation Emitted	Maximum Contamination
Alpha	22 dpm
Beta or Gamma	220 dpm
Low Energy Beta	2,200 dpm

[Counts per minute must be corrected for background and counting efficiency of the instrument to give accurate dpm (disintegrations per minute).]

8.4 Leak Tests

Sealed radioactive sources must be leak tested at least twice a year; however, sources incorporated into devices such as electron capture detectors may be tested at other intervals as recommended by the device manufacturer. Removable contamination on any source more than 0.005 microcurie (μCi) shall cause the source to be immediately withdrawn from use, decontaminated, and repaired or disposed of. Copies of leak test results shall be maintained by the RSO who will file all necessary reports with regulatory authorities.

8.4 Survey Instrument Calibration

Survey instruments assigned to departments shall be calibrated at least annually and immediately following any maintenance (including replacement of batteries). The RSO shall perform or direct the calibrations or provide for calibration services through a vendor. It is the responsibility of the RU or department chair to assure that instruments in need of maintenance or calibration are turned over to the RSO in a timely manner.

Chapter 9 Radioactive Waste

Because of difficulty in disposing of radioactive wastes and the cost involved, researchers shall carefully plan experiments to minimize waste and choose isotopes which can be most easily disposed of. Mixed wastes (radioactive waste combined with hazardous and/or infectious waste) are especially difficult to dispose of; therefore, every effort shall be made to avoid creation of mixed wastes. Departments

generating mixed wastes may be held fully responsible for costs associated with management and/or disposal of such wastes.

Radioactive waste shall be collected in appropriate containers which can be sealed against leaks or spills, and stored in a secure, properly marked area until disposal is affected. Containers must be clearly labeled with an inventory of the contents, date accumulation started and ended, and the words "RADIOACTIVE WASTE." It is the responsibility of laboratory personnel to assure that housekeeping personnel are informed of the presence of these containers and that such containers are not to be emptied.

Wastes containing radionuclides with half-lives of less than ninety (90) days should be held for at least ten (10) half-lives (decaying to background levels as confirmed by surveys), then disposed of as normal solid waste after obliterating radioactive markings. However, wastes which are contaminated with hazardous chemicals or infectious agents must be disposed of as hazardous or infectious waste after decaying to background levels. Records reflecting decay time, survey methods and results, and final disposition of waste material are a necessity; the form included in the appendix may be used for this purpose.

Certain aqueous scintillation fluids may be disposed of via sanitary sewer so long as all the following conditions are met:

- Vials contain H-3 or C-14 in concentrations not greater than 0.05 $\mu\text{Ci/g}$ of solution,
- Limits set in 0400-20-05-.122 are not exceeded,
- There are no hazardous chemicals or infectious agents associated with the contents, and
- Volumes dumped are relatively small and acceptable under the Memphis Sewer Use Ordinance

Aqueous solutions containing other isotopes which have decayed to background levels or are of acceptably low activity may also be released into the sanitary sewer provided they contain no other hazardous constituents. Proper records must be maintained on disposal via sanitary sewer. Empty vials may be placed in normal solid waste after decontamination.

Non-aqueous solutions meeting the above criteria must be held for disposal as hazardous waste.

Scintillation vials of materials having similar waste components and characteristics should typically be emptied into a common container of no more than one (1) gallon in size, properly labeled, and held for disposal. The empty vials may be decontaminated and disposed of in the building solid waste. Where triple rinsing does not properly decontaminate vials, they must be held for disposal by one of the University waste contractors. Call Environmental Health and Safety at 678-4672 for guidance prior to beginning such operations.

All items not meeting the above criteria must be held for disposal as radioactive, hazardous, or infectious waste. Notify Environmental Health and Safety to schedule proper disposal.

Chapter 10 Emergency Procedures and Security

Each area containing radioisotopes in liquid form must have a conspicuously posted spill control procedure and have a readily accessible spill control kit which includes absorbents or other material suitable for diking and absorbing spills, a chemical resistant container for holding waste, appropriate personal protective equipment, and materials such as sodium bicarbonate or citric acid (when appropriate) for neutralizing spills.

In the event of a spill or other accident involving radiation or radioisotopes, the following procedures should be followed in addition to guidance provided in the posted spill control procedure.

10.1 Minor Spills or Contamination of Surfaces

The laboratory supervisor will notify all personnel in the vicinity immediately. The extent of contamination will be determined, and appropriate measures taken to prevent further spread. Individuals in the room or area who might be contaminated will be checked and instructed to remove contaminated clothing and wash affected areas if necessary. Contaminated surfaces will be cleaned by laboratory personnel. A report will be made to the Radiation Safety Officer.

10.2 Major Spills Involving Radiation Hazard to Personnel

The laboratory supervisor or other person in charge of the laboratory will take charge of the emergency. All personnel in the room or area will be notified to vacate immediately. Any action that can be taken immediately to prevent the spread of contamination such as closing doors, shutting off ventilation systems, spreading absorbent material, etc., will be taken provided such action does not cause excess radiation exposure or other danger to individuals involved.

The person in charge will notify the Radiation Safety Officer at 678-4672, or the University Police (678-HELP) if the accident occurs outside normal working hours. Individuals involved will be checked for contamination and instructed to remove contaminated clothing and wash affected areas if necessary. Employees needing medical attention will follow the established Workers' Compensation procedures when seeking medical attention. Students may contact Student Health Services for guidance on medical treatment. Personnel with serious injuries will be transported to an appropriate medical facility by Memphis Fire Department Ambulance.

Contaminated areas will be defined and posted. A clean-up plan will be devised and decontamination will proceed as soon as practicable. An investigation will be made by the RSO and/or the Radiation Safety Committee.

10.3 Accidents Involving the Release of Airborne Radioactive Materials

All personnel will be notified to vacate the area. All fans and ventilating systems will be shut down, and the individual in charge will, if possible without excess radiation exposure or other danger, secure all doors and vents and attempt to isolate and seal the area. Individuals involved will be checked for contamination and instructed to remove contaminated clothing and wash affected areas if necessary.

The individual in charge will notify the Radiation Safety Office (678-4672) or the University Police (678-HELP). The hazard will be evaluated and equipment necessary for safe re-entry will be obtained. The area will be surveyed, and decontamination will be performed as soon as practicable.

10.4 Accidents Involving Possible Overexposure of Personnel

All accidents involving the possible overexposure of personnel must be reported to the Radiation Safety Officer immediately. Operations related to the possible overexposure must be suspended until authorized to resume by the RSO or Radiation Safety Committee.

10.5 Follow-up Procedures for All Incidents

A report will be made to the Radiation Safety Officer by the laboratory supervisor. Except for very minor incidents, an investigation will be conducted by the RSO and/or RSC. The RSC will determine what actions are necessary or desirable to prevent further occurrences. Where required, a report will be submitted to appropriate regulatory agencies by the RSO.

If there is a reasonable probability that any individual has ingested or inhaled radioactive material, procedures will be initiated to determine the extent of internal contamination and the radiation dose received. Procedures such as urine or fecal counts may be done locally under supervision of the RSO. If additional procedures such as whole-body counting are required, the individual will be transported to a facility capable of the required procedure. Medical assistance will be obtained if necessary.

All clean-up work will be done in a manner that will minimize the exposure of personnel and spread of contamination. Any release of radioisotopes during clean-up will conform to regulatory requirements.

10.6 Security

All areas housing licensed materials or registered devices shall be secured against unauthorized entry when unattended and during off duty hours. Radiation areas and high radiation areas shall be always secured against unauthorized entry.