

RADIATION SAFETY MANUAL

UNIVERSITY OF ALABAMA
OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY
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INTRODUCTION

The University of Alabama uses radioactive isotopes and radiation producing machines under a general license from the Bureau of Radiological Health, Department of Health, and State of Alabama. For purposes of these regulations, The University of Alabama is treated as one individual person. Therefore, the Bureau issues licenses to possess and use radioactive materials and radiation producing machines to the University, which in turn approves and sublicenses individual users within the University.

This manual has been approved by both The University of Alabama and the Bureau of Radiological Health of the State Department of Health and must be followed by all users of radioactive materials and radiation producing machines on the University campus. As part of the license granted to the University, changes and amendments may be made only by approval of the State of Alabama Department of Public Health.

The objectives of the radiation safety program are to ensure the responsible use of radiation, to reduce University liability, to ensure University compliance with applicable regulations and to promote the As Low As Reasonably Achievable (ALARA) concept for all exposures. In order to achieve these objectives, the continued support of all sublicensees and users is essential.

Hal Barrett
Director, Environmental Health and Safety
Radiation Safety Officer

A) PHILOSOPHY OF MANAGEMENT

1. The As Low As Reasonably Achievable (ALARA) concept for radiation exposures shall be utilized as the basic philosophy for radiation safety management and operation.
2. The ALARA philosophy means that each person should maintain exposures as low as reasonably achievable, regardless of exposure limits.
3. All University personnel have the responsibility of ensuring the ALARA philosophy is applied to employees, students, visitors, clients and clinical patients.
4. The responsibility for enforcement of the ALARA philosophy shall reside with each sublicensee and user of radioactive materials or machines.
5. The radiation safety program shall be reviewed annually for program content, implementation and efforts to maintain ALARA exposures.

(B) GENERAL INFORMATION AND GUIDELINES

1. An area is considered to be contaminated when the survey swipe count exceeds 2000 dpm/100 cm², or when the radiation detection meter reading exceeds twice the background reading. An action level of 200 cpm/100 cm² may be used to define contamination.
2. Following contamination remediation, an area is considered to be decontaminated when the count returns to less than 2000 dpm/100cm², or the removable contamination level is reduced to less than the action level.

3. Persons under 18 years of age are prohibited in areas where radioactive materials or radiation producing machines are used or stored unless written permission is obtained from the RSO.
4. Information listing all persons, who work or attend class in an area where radioactive materials or radiation producing machines are used or stored, shall be provided by the sublicensee to the RSO. This list shall be updated whenever personnel, students, or the corresponding information changes.
5. Information to be included in this list shall be name, social security number, verification that workers are at least 18 years old, sex, employment status and mailing address.
6. Each sublicensee may have Authorized Representatives, who may sign forms and place orders on the behalf of the sublicensee.
7. Information including name, social security number, education, training and experience shall be submitted by the sublicensee, through a Sublicense Amendment Application, to the RSO for each Authorized Representative.
8. The RCAC shall approve each Authorized Representative.
9. The RSO must be informed of any change, termination or addition of an Authorized Representative.
10. More than one individual may be sublicensed for a particular machine or area. However, these are special cases and should only be allowed if issues of supervisory control or responsibility are in question.
11. The RSO is available to answer questions or provide radiation safety information to any staff, faculty member or student of The University of Alabama.
12. The Assistant RSO may act as RSO for The University of Alabama in the absence of the RSO or as conditions merit.
13. The RSO shall be immediately informed of any sources received on a manufacturer's general license.
14. For the purposes of this manual, the Agency refers primarily to the Alabama Department of Public Health but may also apply to other regulatory agencies such as the Nuclear Regulatory Commission.

(C) GENERAL SAFETY PRACTICES

1. The University of Alabama Chemical Hygiene Plan and Laboratory Guide requirements shall apply to all areas that use radioactive materials or radiation producing machines.
2. Eating, drinking, smoking and the application of cosmetics are prohibited in areas where radioactive materials or machines are used or stored.
3. Food shall not be stored in posted areas where radioactive materials or machines are used or stored.
4. Appropriate personal protective equipment (PPE) such as gloves, shoe covers, lab coats, etc. shall be made available and utilized as appropriate.
5. Eye protection shall be worn at all times by persons in the lab or area where radioactive materials or machines are used or stored if a significant potential for an eye injury exists.
6. Shielding appropriate to the degree and type of hazard shall be immediately available and utilized as needed.
7. Laboratories or areas where radioactive materials or machines are used or stored shall be locked at all times when personnel are not present.

8. Only authorized individuals shall enter areas that use or store radioactive materials or radiation producing machines.
9. All losses of radioactive materials shall be immediately reported to the RSO.
10. The RSO and sublicensee shall maintain all documentation associated with losses of radioactive materials.
11. All radiation work must be conducted in areas where access to a telephone or an emergency communication device is available.
12. All individuals who work with radioactive materials or radiation producing machines shall do so under the supervision of an approved sublicensee or an approved representative.
13. All radiation sources and machines shall be secured to prevent unauthorized removal or operation.
14. Persons shall be prohibited unauthorized or inadvertent entry to high or very high radiation areas by one or more of the following methods:
 - a. Interlocking control switches.
 - b. Visible and audible alarms that will alert the supervisor of the activity of the entry.
 - c. Locked entryways with positive control of continuous direct or electronic surveillance.

(D) RADIATION CONTROL ADVISORY COMMITTEE (RCAC)

1. The RCAC has the responsibility for the following:
 - a. Approve all uses of radioactive materials and radiation producing machines that are sublicensed under the University of Alabama general License #164.
 - a. Approve all uses of radioactive materials and radiation producing machines that are sublicensed under the University of Alabama general License #164.
 - b. Advise the RSO and support the radiation safety program.
 - c. Assist the RSO with enforcement of regulations and guidelines.
 - d. Review the radiation safety program annually to determine if the program is effective and compliant with regulations.
 - e. Advise the Vice President of Research on matters concerning the uses of radiation.
2. The chair of the RCAC shall be a University employee who is sublicensed or qualified to be sublicensed and accepted as chair by the State Bureau of Radiological Health.
3. The RCAC shall meet at least once each calendar quarter.
4. The membership of the RCAC shall be approved by the RSO.
5. A majority of the RCAC membership must be approved sublicensees.
6. To be considered an official meeting of the RCAC at least three voting members must be present.
7. The Chair of the RCAC shall moderate all meetings. In the absence of the Chair, the RSO shall serve as moderator, and the meeting will be official if three voting members are present.
8. A member of the RCAC or a person designated by the RCAC moderator shall keep the minutes of the meeting. This person shall be responsible for distribution of the minutes.

9. The RCAC may revoke a sublicense or take other punitive action if an individual disregards radiation safety procedures, fails to adhere to the provisions of the UA Radiation Safety Manual or habitually creates radiation hazards.

(E) RADIATION SAFETY OFFICER (RSO)

1. The University of Alabama shall appoint a Radiation Safety Officer (RSO) who is approved by the State and who is responsible for implementing the Radiation Safety Plan.
2. The RSO shall investigate overexposures, accidents, spills, losses, thefts, unauthorized receipts, uses, transfers, disposals and deviation from accepted practices and implement corrective action.
3. The RSO shall be responsible for the written policies for:
 - a. Authorizing the purchase of material.
 - b. Receiving and opening packages.
 - c. Storing radioactive material.
 - d. Keeping an inventory of radioactive material.
 - e. The safe use of radioactive materials and radiation producing machines.
 - f. Taking emergency action if control of radiation material is lost.
 - g. Performing contamination surveys.
 - h. Performing checks of survey instruments and safety equipment.
 - i. Disposing of radioactive material.
 - j. Training personnel.
 - k. Maintaining all records and reports designated as the responsibility of the RSO by this manual.
4. The RSO shall serve as a voting member of the RCAC.

(F) SUBLICENSE TYPES

5. There are three types of sublicenses, correlating to the type of radiation used. They are:
 - a. Sealed Source
 - b. Radiation Producing Machine
 - c. Unsealed Source
6. In general, sealed sources include items such as, but not limited to, gas chromatograph ECD's, lead detectors and sources used for calibration or academic instruction.
7. In general, radiation producing machines include items such as but not limited to, analytical x-ray machines and particle accelerators.
8. In general, unsealed sources include research or work involving unsealed radioactive materials.
9. Personnel must be sublicensed for each of the three types through the sublicense approval process.
10. Sublicenses for the following radioactive materials and radiation producing machines may not be required. The RSO should be consulted to determine if a university sublicense is appropriate or if other regulations apply.
 - a. Medical and therapeutic uses.

- b. Machines producing x-rays as a secondary radiation source (e.g. electron microscopes).
- c. Exempt sources.
- d. Naturally occurring isotopes in small quantities.
- e. Daughter products of the original sublicensed radioactive material, if the daughter products will not be used for research or teaching.

(G) SUBLICENSE APPROVAL PROCEDURE

1. Faculty and staff who wish to use radioactive isotopes or radiation producing machines must submit a Sublicense Application to the RSO.
2. The Sublicense Application shall request information concerning training, educational background, experience, a general project outline, description of facilities and equipment, and other information.
3. All applicable sections of the Sublicense Application must be completed in order to be considered.
4. Applications requiring completion of information or needing additional information will be returned to the prospective sublicensee for action.
5. Upon completion, the Application should be returned to the RSO for review.
6. The RSO shall review the Application and make a written recommendation concerning acceptance, rejection or modification.
7. The completed Sublicense Application and recommendations of the RSO shall be presented to the RCAC for consideration of approval.
8. The RCAC may approve, modify, or deny the Application as voted by the majority of members present after sufficient review.
9. In certain situations an Application may be reviewed by the RCAC without a scheduled meeting. In these instances the application shall be reviewed by the membership of the RCAC and their recommendations returned to the RSO. Recommendations for approval or disallowance may be submitted electronically or by facsimile in the form of a vote. Verbal approval or disallowance is not permitted.
10. Upon approval, each sublicense shall be assigned a control number and an expiration date. This sublicense control number must be obtained prior to any work with or the ordering of radioactive materials or radiation producing machines.
11. Initial sublicense approval shall only be considered for those personnel requesting active status. (See section H for status categories.)
12. All sublicense Applications which involve work with animals must also be approved by the Director of the Animal Care Facility and the Institutional Animal Use and Care Committee.

(H) SUBLICENSE STATUS

1. Sublicenses will be under active status or inactive status.
2. Active sublicenses require completion of all the applicable conditions as set forth in this manual.

3. Inactive status may be used when an individual wishes to maintain the privileges of a sublicensee but does not currently possess any radioactive materials or radiation producing machines.
4. Sections A-E, O-Q, W and C1 of this manual shall apply to an inactive sublicensee:
5. A change in sublicense status must be approved by the RSO.
6. Sublicense privileges and designation may be terminated at any time upon the written request of the sublicensee, which shall be submitted to the RSO.
7. Once active status is approved, it shall remain in effect until August 31 of each year. For example, active status approved July of 2007, would be in effect until August 31, 2007, and active status approved September 1, 2007 would be in effect until August 31, 2008.

(I) SUBLICENSE AMENDMENTS

1. Sublicenses may request an amendment to their existing sublicense by application to the RSO.
2. Amendments, which require the approval of the RCAC, shall be reviewed by the RSO, who will make a recommendation to the RCAC.
3. Incomplete amendment requests shall be returned by the RSO to the sublicense applicant for completion.
4. The RCAC shall evaluate all amendment requests that require RCAC approval. The decision to approve, deny or modify amendment requests shall be determined by a majority vote of members present.
5. Sublicense amendment requests must be made under the following circumstances:
 - a. Significant change in procedure.
 - b. Addition of isotope(s).
 - c. New x-ray instrument.
 - d. Additional sealed source(s).
 - e. Addition or change of Authorized Representative(s).
 - f. Other situations which may be pertinent, such as transport off campus.
 - g. Modification of a radiation producing instrument.
 - h. Increase in amount of isotope*.
 - i. Different form of isotope*.
 - j. Change in location*.

*Requires RSO approval but does not necessarily require RCAC approval.

6. In certain situations an amendment request may be reviewed by the RCAC without a scheduled meeting. In these instances the request shall be reviewed by the membership of the RCAC, with their recommendations returned to the RSO.
7. Following amendment approval by the RCAC, the RSO shall issue a dated copy of the complete sublicense to the sublicensee. This sublicense, including all amendments, conditions and information, shall supersede all previously issued sublicenses.

(J) SUBLICENSE RENEWAL

1. At the time of approval, each sublicense shall be assigned an expiration date corresponding to the next August 31 (for example see H 7).

2. Sublicenses may be in force for any amount of time up to one year.
3. Prior to August 31 of each year, sublicenses shall be informed by the RSO of the need for renewal.
4. The sublicensee shall provide requested information and return the renewal request to the RSO.
5. Following review, the RSO may approve renewals, which do not request amendments that require RCAC approval.
6. Renewals, which request an amendment to an existing sublicense, must go through the Sublicense Amendment procedure for approval.
7. Sublicenses who do not wish to renew shall so indicate to the RSO in their written or electronic response to the renewal notification.
8. Sublicenses who allow their sublicense to expire must reapply through the Sublicense Approval process prior to working with radioactive materials or radiation producing machines.

(K) SUBLICENSEE SAFETY SURVEYS

1. Persons who work with unsealed sources (except for those who use isotopes undetectable with portable instruments) shall use appropriate portable radiation detection instruments to monitor their hands, shoes, skin and clothing frequently when working with the sources and prior to leaving the work area.
2. Surfaces within the work area shall be surveyed each day following completion of work for that day to determine if contamination is present.
3. Surfaces found to be contaminated with radioactive material shall be decontaminated immediately. A follow up survey shall be performed and records shall be maintained which document decontamination.
4. Work surfaces utilized for the containment of radioactive materials or hazards such as the interior of a fume hood are exempt from safety survey decontamination requirements.
5. Persons who discover contamination on their hands, shoes, skin or clothing shall begin decontamination immediately. A follow-up survey shall be performed and documented to verify decontamination.
6. The responsible sublicensee and the RSO shall be informed immediately of any contamination of an individual. The RSO shall determine if medical attention is necessary.
7. Safety surveys may be conducted with appropriate portable survey instruments, as determined by the RSO or by swipe tests followed by analysis with a scintillation counter.
8. See Section B (General Information and Guidelines) for contamination and decontamination levels.

(L) RSO CONTAMINATION SURVEYS

1. The RSO or designee shall perform contamination surveys in all active sublicensed labs or areas which utilize unsealed sources.
2. These surveys shall be performed by the RSO or a designee each month.

3. The contamination survey shall consist of a general survey with a portable survey meter followed by smears taken from suspected contaminated areas and refrigerators as applicable. It is not necessary to record data from the general survey.
4. Sublicenses shall be informed by the RSO of areas found to be contaminated and the appropriate decontamination procedures to be taken.
5. Following decontamination, a subsequent survey shall be performed in order to ascertain the effectiveness of the decontamination process.
6. The RSO shall maintain records associated with contamination surveys performed by EHS representatives.
7. See Section B (General Information and Guidelines) for contamination and decontamination levels.

(M) INVENTORY OF UNSEALED SOURCES

1. An accurate inventory of all unsealed sources, which are in possession of a sublicensee, shall be maintained by each sublicensee and updated on the last workday of each calendar month.
2. Each month the RSO or a designee shall inspect inventory records to determine if they are complete and accurate.
3. Sources for which an individual is sublicensed but are not currently in possession need not be inventoried. However, it must be recorded in the inventory records that the isotope in question was not possessed for that month.
4. If for any period during the month, a source is in possession, then the inventory record must be completed for the month.
5. Inventory amounts shall be recorded in units of activity (Ci, mCi or uCi).
6. The RSO must approve all transfers of isotopes or sources in order to balance inventories.
7. The RSO shall maintain inventory records which will detail the amount of each source on campus, its location and the responsible sublicensee. This inventory shall be updated at least monthly by the RSO.

(N) SEALED SOURCE SURVEYS

1. Non-alpha sealed sources shall be surveyed for leakage at least every six months by the RSO. Alpha sealed sources shall be surveyed by the RSO for leakage at three month intervals. Exempt sources are not included in this requirement.
2. Sources that have removable contamination in excess of 0.005 uCi shall be taken by the RSO and placed in storage.
3. All sealed sources must have been leak tested by the manufacturer within six months of receipt by The University of Alabama, and documentation of this test shall be provided and maintained by the responsible sublicensee.
4. If at any time there is reason to suspect leakage (such as damage to the source), the RSO shall be informed and leak testing conducted.
5. Tests for leakage of sealed sources shall be capable of detecting the presence of 0.005 uCi of removable radioactive material.

6. Sealed sources which are in storage at the Radiation Safety Facility and are not being used, do not require leak testing. However, sealed sources which are removed from storage for use must be leak tested prior to use.
7. Exempt sources and sealed gas sources are not required to be leak tested.
8. Quarterly inventory of all sealed sources shall be performed by the RSO.

(O) PURCHASES, SHIPMENTS AND TRANSFERS

1. All requisitions or requests for radioactive materials or machines must be approved by the RSO before the purchase requisition is sent to the vendor.
2. Purchase approval numbers shall be assigned by the RSO before the order is placed.
3. All unsealed source isotope orders shall be shipped directly to the Office of Environmental Health and Safety.
4. The RSO or designee shall check each package for leakage and contamination. Monitoring and delivery shall be performed within three hours of receipt if the package is received within normal working hours or not later than three hours from the beginning of the next workday if the package is received after 3 PM of the normal workday.
5. Documentation of package monitoring shall be maintained by the RSO. The package shall not be delivered and the delivery carrier shall be immediately notified when:
removable surface contamination exceeds 0.01 uCi (22,000 dpm) per 100 cm² of package surface, radiation levels on the surface are in excess of 200 mrem/hr, or radiation levels at one meter from the surface are in excess of 10 mrem/hour.
6. Leaking or contaminated packages will be managed by the RSO and not distributed.
7. The RSO or other EHS employees shall deliver packages to the sublicensee or other persons designated to receive packages for the sublicensee.
8. The RSO must be notified of all off campus shipments to verify that they are packaged, labeled and managed according to all applicable regulations.
9. All purchases of radioactive materials or equipment must be authorized by the responsible sublicensee or sublicensee representative. This includes material and equipment which is donated.
10. The RSO must be notified prior to any transfer of sources between University sublicensees. Both the donor and recipient sublicensees must acquire RSO approval of the transfer and must maintain documentation of the approval.
11. The RSO must be consulted prior to any off campus transport of radioactive material or radiation producing machines. At a minimum, RCAC approval is required. Therefore, a sublicense amendment request must be submitted to the RSO. In some cases State or NRC approval may be necessary.

(P) EQUIPMENT CALIBRATION

1. Portable survey instruments shall be calibrated at least annually by the RSO, the manufacturer or a calibration vendor and more often if damage occurs or if there is reason to suspect the instrument is not working properly.
2. The RSO or designee shall collect survey instruments for calibration at the appropriate time interval. The RSO or designee will return the instrument following calibration.
3. Calibration results shall be affixed to the instrument.

4. The RSO shall maintain all records relating to instrument calibration.

(Q) LABELS AND SIGNAGE

1. Entrances to labs or other areas shall be posted with signage warning of hazards which are present and any prohibitions.
2. All radiation related signage shall be approved by the RSO. Other required signage shall be approved by EHS.
3. Containers of radioactive materials shall be labeled with information including the isotope, the activity at reference date, the radiation hazard symbol and the words, "Caution Radioactive Material".
4. The three bladed design of the prescribed radiation symbol shall be magenta, purple, or black on a yellow background.
5. Labels shall be defaced or removed prior to disposal of used uncontaminated containers.
6. Each area designated as a Radiation Area shall be conspicuously posted with signage bearing the radiation symbol and the words "Caution Radiation Area".
7. Each area designated as a high radiation area shall be conspicuously posted with signage bearing the radiation symbol and the words "Danger High Radiation Area".
8. Each area with airborne radioactive material shall be conspicuously posted with signage bearing the radiation symbol and the words, "Danger Airborne Radioactivity Area".
9. Each area where non-exempt radioactive materials or sources are used or stored shall be posted with signage bearing the radiation symbol and the words, "Caution Radioactive Materials".
10. Labels and signage for analytical x-ray equipment are addressed in section (A1).

(R) FACILITY AND EQUIPMENT APPROVAL

1. The RSO must review and approve, prior to use, mechanical or powered equipment, which will be used with radioactive materials.
2. The RSO must review and approve prior to utilization all laboratories or other areas in which radioactive materials will be used or stored.
3. Any significant changes in the equipment or facility must be approved by the RSO prior to subsequent use.
4. All hoods in which radioactive materials will be used or stored must be prior approved by the RSO.
5. The RSO or other EHS representative shall monitor all approved hoods at least annually for operational effectiveness.

(S) MONITORING AND EXPOSURES

1. Dosimetry shall be used whenever:
 - a. Working with equipment such as x-ray machines or other sources capable of producing ionizing radiation.
 - b. Individuals work with neutron emitters.
 - c. Specified by the RSO.

2. Persons who work with C-14, H-3 or S35 shall not use external dosimetry.
3. The RSO shall be notified in writing of the need for dosimetry. The RSO shall be informed in writing of the termination of dosimetry. The RSO may terminate dosimetry if the sublicensee fails to terminate dosimetry as appropriate.
4. The occupational exposure limit is established at 5 rem per year.
5. Personnel shall report to their sublicensee, who shall report to the RSO, all doses (such as occupational, non-medical or inadvertent exposures) received outside the University of Alabama. These doses shall be considered part of the occupational exposure limit. Routine medical or dental x-rays are not included in this requirement.
6. On dates specified by the RSO, each Sublicensee shall place all dosimeters used under his/her supervision in a designated place for pickup.
7. Individuals who fail to make available their film badge or dosimeter on the specified pickup date, may be issued a warning for the first violation. Any repeat violation within a twelve month period may result in the procedure as described in section (D1).
8. All exposures in excess of 100 mrem/month or 300 mrem/quarter shall be investigated by the RSO.
9. Investigation results and recommendations shall be provided by the RSO to the individual, their responsible sublicensee, and the RCAC.
10. All inadvertent or unintentional exposures shall be immediately reported to the responsible sublicensee and the RSO regardless of the expected level of exposure.
11. Minors are limited to 10% of the adult dose limit.
12. The occupational doses to an embryo/fetus shall not exceed 0.5 rem for the entire pregnancy.
13. The total effective dose equivalent to the public shall not exceed 100 mrem/year and 2 mrem in any hour.
14. Biological samples are required of persons who work with unsealed sources of certain radio nuclides of quantities at or above the amounts shown below if there is a significant potential for ingestion, inhalation or absorption of radioactive materials.

C-14..... 20 mCi
H-38 mCi
I-125..... 1 mCi
S35..... 2 mCi

15. It is the responsibility of the sublicensee to notify the RSO when work is started for which biological samples may be required.
16. Personal dosimetry, when not being worn, shall be stored within the lab as specified by the RSO.

(T) VISITORS

1. Visitors to areas where radioactive materials or radiation producing machines are used or stored shall mean individuals who routinely do not work or attend classes in areas of this type on The University of Alabama campus.
2. Maintenance workers, housekeepers and other personnel who, as a routine part of their employment are in areas where radioactive material and radiation producing machines

are used or stored are not considered visitors. Therefore, personal dosimetry is not required unless the area is classified as a high or very high radiation area. However, in all cases, personnel shall obtain information from the sublicensee, lab users or departmental representative concerning specific hazards for the radiation area requiring entrance, prior to beginning work in the area.

3. Those persons who are patients in a medical facility within an area where radioactive materials or radiation producing machines are used are NOT considered visitors. They are considered exempt.
4. All visitors to radiation areas shall be accompanied by a University sponsor.
5. A sponsor shall be a sublicensee or a University employee, who is knowledgeable of the radiation hazard and safety precautions for the area being visited.
6. Visitors to areas where dosimetry is required shall be issued dosimetry at the time of their visit. It is the responsibility of the sponsor to obtain dosimetry from the RSO.
7. The RSO and applicable sublicensee shall maintain records associated with visitors including name, identifying number, reasons for visit, mailing address, exposure and date of visit.
8. Exposure limits for visitors are 2 mrem in any hour and 100 mrem/year.
9. Sponsors shall instruct visitors in hazards and appropriate safety precautions and shall obtain from the visitor a signed and dated attestation stating that the visitor has received this information.
10. Minors are not authorized to visit a radiation area without specific prior written approval from the RSO.

(U) AIR SAMPLING AND RESPIRATORY PROTECTION

1. If air sampling is needed in conjunction with a process or project in order to determine personal safety, this shall be specified in the sublicense application.
2. Air sampling shall be conducted by the sublicensee or RSO in accordance with the appropriate regulatory guide, which is available from EHS.
3. Air sampling shall be conducted at a frequency specified in the sublicense application.

(V) TRAINING

1. All sublicensees, authorized representatives and users shall complete EHS initial and annual training.
2. Anyone who works with radioactive materials or radiation producing machines shall receive initial training and information from their sublicensee.
3. The sublicensee shall provide females with specific training concerning the radiation hazard to a fetus and associated potential reproductive abnormalities. This training shall be provided to all females and documentation shall be maintained by the sublicensee. Information to be covered shall conform to the appropriate regulatory guide, which is available from EHS.
4. It is the responsibility of the individual to inform her sublicensee of a suspect or actual pregnancy. Individuals may not be questioned as to their pregnancy status.
5. Sponsors shall instruct visitors in safety precautions.

6. Any personnel who administer training shall maintain records of training including name, social security number and a written example of material covered.
7. A test shall be given to all persons who receive the initial Radiation Safety Training Course(s).
 - a. The test should encompass the information covered in the training session(s).
 - b. Eighty per cent correct answers is a passing grade.
 - c. To work with isotopes or in a radiation area, an individual must complete training and pass the accompanying test.
8. Additional training shall be provided by the sublicensee whenever conditions change.
9. Training provided by the sublicensee shall include, at a minimum, emergency procedures, decontamination procedures, radiation safety principals and other information related to radiation hazards and other hazards which are present in the area where the individual will be working.
10. Personnel who do not work with radiation sources but must work in a lab or area which is required to be posted with the appropriate radiation hazard signage shall receive training and information.

(W) INSPECTIONS, NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS

1. The University of Alabama shall have available current copies of the following documents:
 - a) State regulations
 - b) Radiation Safety Program Manual
 - c) The University of Alabama license and amendments
 - d) Operating procedures applicable to the license.
 - e) Notices of violation or orders issued and The University of Alabama response.
2. State Agency Form X "Notice to Employees" shall be posted wherever individuals work in or frequent a restricted area.
3. State Agency documents requiring to be posted shall be posted within two working days of receipt and shall remain posted for five days or until action correcting the violation has been completed.
4. Exposure data for individuals shall be reported at least annually.
5. Within 30 days of request, the RSO shall furnish an exposure report to workers formally engaged in radiation activities at The University of Alabama.
6. The RSO of The University of Alabama shall provide upon request an exposure report for workers who are terminating employment.
7. The RSO of The University of Alabama shall afford the agency, at all reasonable times, an opportunity to inspect machines, activities, facilities, records, etc.
8. The Agency inspectors may consult privately with workers.
9. Agency inspectors may refuse to permit accompaniment by any individual who interferes with a fair and orderly inspection.

10. During an inspection any worker may bring to the attention of the agency inspector any past or present condition which he/she has reason to believe may have caused a violation of regulations.
11. Any worker who believes that a violation of the State regulations or The University of Alabama license exists or has occurred may request in writing an Agency inspection.
12. Any Notice of Violation or order issued by the State shall be posted for a period of five workdays.

(X) EMERGENCY PROCEDURES

1. Spills or releases which contaminate an area or individual shall be immediately reported to the RSO.
2. Decontamination shall be carried out by the sublicensee as directed by the RSO.
3. Decontamination shall be carried out until the contamination level is less than 2000 dpm/100cm² or below the action level of 200cpm/100cm².
4. Personnel involved in decontamination shall utilize personal protective equipment appropriate for the task.
5. Personnel shall be instructed by the sublicensee to wash immediately with soap and water if the skin is contaminated and to immediately remove any contaminated clothing.
6. Personnel shall be instructed by the sublicensee to immediately contact the RSO if washing does not remove the contamination.
7. Information concerning personal and area decontamination shall be provided by the sublicensee and posted in each lab or area where radioactive materials are used.
8. Personnel in areas affected by a spill or release shall be given immediate warning of the potential hazard.
9. Records concerning spills, remediation, notifications, contamination testing and other actions associated with spills or releases shall be maintained by the sublicensee and the RSO.
10. Personnel and students shall be trained by the sublicensee in emergency procedures to be used in the event of an accident or emergency.
11. The UA Emergency Operations Plan shall be used as a reference during major emergencies.
12. Students who receive injuries while working with radioactive sources shall be treated at the University Medical Center.
13. Employees who receive injuries while working with radioactive sources shall be treated at University Medical Center.
14. Persons injured after hours shall be treated at DCH Medical Center.
15. Information concerning contamination status shall be provided to the attending physician by the sublicensee.
16. All injuries which occur while working with radioactive sources shall be immediately reported to the RSO.
17. The sublicensee shall prepare a written report conferring all aspects of a spill, release or injury and submit it to the RSO.
18. If applicable, the RSO will file an incident report with the State Bureau of Radiological Health.

19. Each laboratory or area shall have immediately available within the work area an emergency kit to be used in the event of a spill or leak. The kit shall contain absorbent materials, personal protective equipment and other items necessary for remediation and decontamination of the spilled material.

(Y) WASTE MANAGEMENT

1. Radioactive waste material shall be collected at the site of generation.
2. Waste containers shall be labeled with isotope, activity as of reference date, chemical constituency, generator, building, room number and the radiation hazard symbol.
3. Waste containers shall be approved by the RSO.
4. Waste shall be collected by the RSO or designated EHS personnel upon notification by the generator.
5. Sharps containers shall be utilized for the disposal of sharps contaminated with radioactive materials. These containers shall be managed as radioactive waste unless the level is below the exempt level.
6. Specific instructions for wastes of high toxicity or activity (>5 mCi) must be obtained from the RSO. Written instructions from the RSO shall be posted and reviewed with applicable personnel or students
7. Waste received by the RSO shall be initially logged in at the Radioactive Waste Storage Area (RWSA) and assigned a unique waste control number.
8. The disposition of the radioactive waste shall be determined by the RSO.
9. Once disposition is determined, the waste shall be placed in a specified area along with other wastes of the same disposition.
10. Disposal vendors must be permitted and records shall be maintained by the RSO of all permits, manifests, etc.
11. Sublicenses or personnel other than the RSO may not dispose of any quantity of radioactive waste in any manner.
12. First washings from glassware shall be collected and treated as radioactive waste. Subsequent washings shall be treated as non-hazardous effluents unless otherwise directed by the RSO.
13. Material may be disposed of by the RSO by transfer to an authorized disposal vendor, decay in storage, or by other methods as authorized by the State.

(Z) ANALYTICAL X-RAY EQUIPMENT REQUIREMENTS

1. Radiation equipment such as x-ray machines shall be equipped with operational interlocking warning lights, which will indicate to anyone approaching the area that the equipment is in operation.
2. The interlocking device shall incorporate security to turn off the machine or close the shutter whenever a specified safe boundary (i.e. a door) is exceeded.
3. A safety device such as a guard or interlock which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into the path shall be provided on all open-beam configurations.
4. A positive visible warning light labeled with the words "X-ray On", shall be located:

- a. Near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized.
 - b. At a conspicuous location visible at all local components.
5. Open beam configurations shall be provided with a readily discernible indication of x-ray tube status (on-off) and/or shutter status (open-closed).
6. Unused ports on radiation source housings shall be secured in the closed position.
7. All x-ray equipment shall be labeled with signage bearing the radiation symbol and the words:
 - a. "Caution - High Intensity X-ray Beam", on the x-ray source showing, and;
 - b. "Caution Radiation - This Equipment Produces X-rays When Energized", near any switch that energizes an x-ray tube or in a conspicuous location if the source is a two-way tube.
8. On open beam configurations each port on the source housing shall be equipped with a shutter that cannot be opened unless a collimator or shielding coupling has been connected to the port.
9. Each x-ray tube housing shall be constructed so that with all shutters closed the leakage measured at a distance of 5 cm is not capable of producing a dose in excess of 2.5 mrem in one hour at any tube rating.
10. Each x-ray generator including rectifiers, transformers and amplifiers shall be equipped with a cabinet that limits leakage so that at a distance of 5 cm it is not capable of producing a dose in excess of 2.5 mrem in one hour.
11. Each entrance to a room containing x-ray equipment in unattended operations shall have a warning light with the words "x-ray on".
12. For open beam configuration, during unattended operation there shall be an interlock device that will shut off the equipment upon the entry of unauthorized personnel.
13. The components of an x-ray system shall be located and arranged in such a manner and shall include sufficient shielding or access control so as to prevent any individual from possible exposure to the excess of any specified limits.
14. Surveys with appropriate instruments shall be performed quarterly on all operational non-clinical x-ray systems, following any maintenance requiring disassembly or removal and whenever a visual inspection reveals an abnormal condition.
15. The RSO or designee shall conduct a survey with appropriate instruments:
 - a. At installation
 - b. Following any change or modification
 - c. Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limit.
16. Each area or room containing x-ray equipment shall be conspicuously posted with signage bearing the radiation symbol and the words "Caution X-ray Equipment".
17. Normal operating procedures shall be written and available to all workers who will operate the equipment.
18. No person may operate x-ray equipment in any manner other than that specified in the procedures, unless written approval of the RSO is obtained.
19. No person shall bypass a safety device unless written approval is obtained from the RSO.

20. When a safety device has been bypassed the source housing shall be posted with signage which states "Safety Device Not Working".
21. No person shall be permitted to operate or maintain analytical x-ray equipment unless the person has received instruction in and demonstrated competence as to:
 - a. Identification of hazards associated with use of the equipment.
 - b. Signage of the warning and safety devices.
 - c. Reasons warning and safety devices have not been installed and the extra precautions required.
 - d. Proper operating procedures for the equipment.
 - e. Biological effects of radiation.
 - f. Procedures for reporting an actual or suspected exposure.
22. Finger or wrist dosimeters shall be used by:
 - a. Workers using systems of open-beam configuration not equipped with a safety device.
 - b. Personnel maintaining x-ray equipment if procedures require a primary x-ray beam when any local component is disassembled or removed.
23. All x-ray machines shall be registered with the RSO who shall in turn register all applicable machines with the agency.
24. The agency shall request renewal of the registration at a time established by the agency.
25. Any change in the name of the registrant or location of the machine, as well as the sale, transfer, disposal or permanent discontinuation of use shall be reported to the agency within 30 days.
26. Electrical equipment which is not primarily intended to produce radiation and does not produce a level greater than 0.5 mR/hr, 5 cm from the surface is exempt from these requirements.
27. The agency may terminate, suspend or modify any registration.
28. The RSO may require sublicensee monitoring with portable instrumentation. If required, the sublicensee shall maintain documentation of monitoring results.

(A1) MEDICAL USAGE OF RADIATION

1. The RSO shall survey clinical equipment for basic safety factors.
2. Medical facilities shall be responsible for maintenance and compliance of their x-ray and other radiation producing machines according to manufacturer specifications and the Bureau of Radiological Health Standards.
3. Medical x-ray equipment shall be calibrated annually by an appropriate vendor representative. Calibration documentation shall be maintained by the clinic or medical facility.
4. A copy of the regulations affecting medical use of x-rays and radioactive materials are available from the RSO upon request.

(B1) RECORDS

1. The RSO shall maintain records of the Radiation Safety Program including: provisions of the program and audits or other reviews of program content and implementation. These records shall be maintained until The University of Alabama license is terminated.
2. Records concerning the results of surveys to determine the dose from external sources shall be maintained until termination of The University of Alabama license.
3. Records concerning individual monitoring data and the assessment of individual dose equivalents shall be maintained until termination of The University of Alabama license.
4. Records concerning the results of individual intake of radioactive material and the assessment of internal dose shall be maintained until termination of The University of Alabama license.
5. Records concerning the results of air sampling, surveys and bioassays shall be maintained until termination of The University of Alabama license.
6. Records concerning the release of radioactive effluents shall be maintained until termination of The University of Alabama license.
7. Upon license termination, records shall be stored on agency form Y and transferred to the agency.
8. Records of tests for leakage or contamination by sealed sources shall be maintained for five years after the record is made.
9. Records concerning prior occupational dose and exposure history shall be retained on agency form Y and maintained for three years after the record is made.
10. For planned special exposure the following records shall be maintained until termination of The University of Alabama license and then transferred to the agency on form Y.
 - a. The circumstances requiring the exposure
 - b. Name of the person authorizing the exposure and a signed copy of the authorization
 - c. Actions which were necessary
 - d. An explanation of why the action was necessary
 - e. Precautions taken to ensure ALARA
 - f. Expected individual and collective doses
 - g. Actual doses
11. The University of Alabama shall maintain records of doses received by all individuals for whom monitoring was done on agency form Z. These records shall include when applicable:
 - a. Deep dose equivalent to the whole body
 - b. Eye dose equivalent
 - c. Shallow dose equivalent to the extremities
 - d. Estimated radionuclide intake
 - e. Committed effective dose equivalent assigned to the intake of radio nuclides
 - f. Information used to calculate the committed effective dose equivalent
 - g. The total effective dose equivalent
 - h. Total of the deep dose equivalent and the committed dose to the organ receiving the highest dose.
12. Records of dose to a fetus shall be maintained with dose records of the pregnant woman.

13. The University of Alabama shall maintain records sufficient to demonstrate compliance with dose limits for the public.
14. The University of Alabama shall maintain records of all waste disposal indefinitely.
15. All records shall be legible and shall be made available to the agency upon request or termination of The University of Alabama license.

(C1) REPORTS TO THE STATE OF ALABAMA DEPARTMENT OF PUBLIC HEALTH (THE AGENCY 1-800-582-1866)

1. Reports concerning lost, stolen or missing sources of radiation shall be made to the agency by telephone as follows:
 - a. Immediately after the occurrence becomes known in a quantity equal to or greater than 1,000 times the quantity in Appendix B of the State regulations.
 - b. Immediately if the situation involves a radiation producing machine.
 - c. Within 30 days after the occurrence becomes known in a quantity greater than 10 times the quantity in Appendix B of the State regulations.
2. Written reports shall be made within 30 days of telephone notification and shall contain the following information:
 - a. For machines - manufacturer, model, serial number, type and maximum energy emitted.
 - b. For isotopes - sealed or unsealed, kind, quantity, chemical and physical form.
 - c. Description of circumstances of the loss or theft.
 - d. A statement of disposition of the source.
 - e. Exposure of individuals.
 - f. Actions taken to recover the source.
 - g. Procedures taken to prevent a reoccurrence.
3. The RSO of The University of Alabama shall immediately notify the agency of an event involving radiation that has caused or threatens to cause any of the following:
 - a. A total effective dose equivalent of 25 rem or more.
 - b. An eye dose equivalent of 75 rem or more.
 - c. A shallow dose equivalent to the skin or extremities or a total organ dose equivalent of 250 rad or more.
 - d. The release of radioactive material inside or outside of a restricted area so that had a person been present for 24 hours they could have received an intake five times the occupational ALI.
4. The RSO of The University of Alabama shall submit to the agency within 30 days a written report after learning of any of the following occurrences.
 - a. Incidents requiring notification.
 - b. Doses in excess of the occupational limits for adults, minors and pregnant women, limit for an individual member of the public, and any limit established in the license.
 - c. A restricted area in excess of limits established in the license.
 - d. An unrestricted area in excess of ten times the applicable limit.

5. Exposure reports shall include:
 - a. Estimate of each individual dose.
 - b. Levels of radiation and concentration involved.
 - c. Cause of the elevated exposures.
 - d. Corrective steps taken or planned to prevent a reoccurrence.
 - e. Name, social security number and date of birth for each individual who is exposed.
6. Reports concerning planned special exposures shall be made within 30 days of the exposure.
7. Reports of leaking or contaminated sealed sources shall be filed with the agency within five days.

(D1) NONCOMPLIANCE ISSUES FOUND BY RSO OR EHS STAFF

1. Noncompliance issues termed “violations” may be classified in one or more of the following categories: initial violation, repeat violation, severe violation and immediately hazardous to health violation.
2. Initial violations are those violations which occur for the first time during a twelve month period.
3. Repeat violations are those violations which occur for the second time during a twelve month period.
4. Severe violations are those violations which occur three or more times during a twelve month period; or for which a clear pattern of repeat violations is demonstrated over time.
5. Immediately hazardous violations are those violations, which are deemed by the RSO as presenting an immediate hazard to persons who may be present in the area or to the facility.
6. Initial violations shall be documented by the RSO or other EHS personnel. The responsible sublicensee shall be informed by the RSO of the nature of the noncompliance, ways to implement correction and the consequences of failure to comply. The Chair of the RCAC and the responsible department chair shall be provided a copy of this documentation.
7. Repeat violations shall be documented by the RSO or other EHS personnel. The responsible sublicensee shall be informed by the RSO of the nature of the noncompliance, ways to implement correction and results of failure to comply. The Chair of the RCAC and the responsible department chair shall be provided a copy of this documentation.
8. Severe violations shall be documented by the RSO or other EHS personnel. The responsible sublicensee shall be informed by the RSO of the nature of the noncompliance; ways to implement correction and that as a result of this noncompliance, the RCAC will evaluate the incident to determine appropriate punitive actions.
9. Immediately hazardous violations shall be documented by the RSO or other EHS personnel. The responsible sublicensee shall be informed by the RSO of the nature of the noncompliance, actions taken by the RSO or EHS and that as a result of the

noncompliance, the RCAC will evaluate the incident to determine appropriate punitive actions.

10. In the event of an immediately hazardous violation, the RSO may immediately take possession of all isotopes and /or radiation producing machines, suspend the privileges of the responsible sublicensee and take other actions as deemed necessary to protect the health of individuals or the safety of University facilities.
11. The RCAC shall invoke punitive requirements or take other actions as deemed necessary in response to severe or immediately hazardous violations.

(E1) RESPONSIBILITIES

1. Each person (employee or student) who uses radioactive material or radiation producing machines is responsible for:
 - a. Complying with all practices, procedures and policies of the Radiation Safety Program (RSP).
 - b. Participating in training programs concerning the requirements of the RSP.
 - c. Planning and conducting each operation in accordance with the RSP Manual and guidelines.
2. Each sublicensee has overall responsibility for radiation safety for their laboratory or area. Responsibilities and duties of the sublicensee are described in this manual.
3. The supervisor of the department or other administrative unit is responsible for supporting radiation safety in that unit.
4. The Assistant RSO may assume the duties and responsibilities of the RSO in the event of the absence or unavailability of the RSO.
5. The duties and responsibilities of the Radiation Safety Officer (RSO) are described in this manual.
6. The responsibilities of the Radiation Control Advisory committee (RCAC) are described in this manual.
7. The President of The University of Alabama has the ultimate responsibility for supporting the goals and requirements of the Radiation Safety Program and shall, with other administrators, provide continual support of this program.

APPENDIX A

Terms and definitions

Absorbed dose	The energy imparted by ionizing radiation per unit mass of irradiation material. The units of absorbed dose are the rad and the Gray (Gy).
Activity	The rate of disintegration (transformation) or decay radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).
Agreement State	Any state with which the United States Nuclear Regulatory

	Commission has entered into an effective agreement under Section 274b of the Atomic Energy Act of 1954, as amended (73 Stat. 689). Alabama is an Agreement State.
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 B, table I of this rule (see Appendix B of this manual). 2. To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the Annual Limit on Intake (ALI) or DAC hours.
Alpha particle A	A positively charge particle emitted by certain radioactive materials; it is identical with the nucleus of the helium atom, being made up of two neutrons and two protons bound together; it is the least penetrating type of radiation and is stopped by a sheet of paper. Because of its low penetrating power, it is not considered particularly dangerous from external exposure. However, the damage to inside tissue by this particle is rather high, so it is considered quite harmful if the emitting substance enters the body.
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 committed effective dose equivalent of 0.05 Sv (5 rem) or a committed dose equivalent of 0.5 Sv (50 rem) to any individual organ or tissue. ALI values for intake by ingestion and by inhalation of selected radio nuclides are given in Table I, columns 1 and 2, of Appendix B.
As low as is reasonably achievable (ALARA)	Making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical, consistent with the purpose for which the licensed or registered activity is undertaken, taking into account the state of technology, the economics of improvements in relation to the 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 nuclear energy and licensed or registered sources of radiation in the public interests.
Atomic number (Z number)	The number of protons (positively charged particles) in the nucleus of an atom; each chemical element has a characteristic atomic number; all isotopes of a given element have the same atomic number.

Atomic weight	The mass of an atom relative to other atoms; approximately equal to the total number of protons and neutrons in its nucleus.
Background radiation	Radiation from cosmic sources; naturally occurring radioactive materials, including radon, except as a decay product of source or special nuclear material, and including global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include sources of radiation from radioactive materials regulated by the Agency.
Becquerel	One basic unit to describe the amount of radioactivity in a sample of material; it equals one disintegration per second. A Becquerel = 2.703×10^{-11} Curies.
Beta particle	A particle emitted from a nucleus during certain types of radioactive decay; stopped by a sheet of metal or acrylic plastic, depending on the emitted energy level of a particular isotope. Beta radiation can cause burns, and beta emitters are harmful if they enter the body.
Bioassay	The determination of kinds, quantities or concentrations 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. For purposes of this manual, "radio bioassay" is an equivalent term.
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. For purposes of this manual, "lung class" and "inhalation class" are equivalent terms.
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_{T50})	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	The sum of the products of the weighting factors applicable to equivalent (H_{E50}) each of the body organs that are irradiated and the committed dose equivalent to these organs or tissues.
Contamination, radioactive	Deposition of radioactive material in any place where its presence may be harmful.

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.
Curie	One basic unit used to describe the amount of radioactivity in a sample of material; it is that quantity of a radioactive substance which undergoes 3.7×10^{10} disintegrations per second, which is approximately the rate of decay of one gram of radium. A commonly used submultiples of the curie is the microcurie (mCi) which is equal to 3.7×10^4 disintegrations per second (dps) or 2.2×10^6 disintegrations per minute (dpm). Under the SI units, a Curie = 3.700×10^{10} Bequerels.
Decay, radioactive	Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles or photons.
Declared pregnant woman	A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.
Decontamination	Removal of radioactive contaminants from surfaces or equipment.
Deep-dose equivalent (H_d)	Applies to external whole-body exposure; the dose equivalent at a tissue depth of 1 cm. (1000 mg/cm^2).
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, results in an intake of one ALI. For purposes of this manual, the condition of light work is an inhalation rate of 1.2 cubic meters of air per hour for 2,000 hours in a year. DAC values are given in table I, Column 3, of Appendix B.
Derived air concentration-hour (DAC-hour)	27. Derived air concentration-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 0.05 Sv (5 rem).
Dose	Quantity of radiation absorbed per unit of mass of a body or by any portion of a body; units of dose measurements are the rad, Gray, the Roentgen, the Coulomb/Kg, the Sievert, and the rem.
Dosimetry processor	An individual or an organization that processes and evaluates individual monitoring devices in order to determine the radiation dose delivered to the monitoring devices.
Effective dose equivalent (H_E)	The sum of the products of the dose equivalent to the organ or tissue and the weighting factors (W_i) applicable to each of the body organs

	or tissues that is irradiated.
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 or machines which produce radiation. 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 or 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).
Film badge	A package of photographic film worn like a badge by persons working with or around radioactive material to measure exposure to ionizing radiation; the absorbed dose can be calculated from the degree of film darkening caused by the irradiation.
Gamma radiation	High energy, short wavelength, ionizing, electromagnetic radiation emitted by nuclei of many radioactive atoms during radioactive decay.
Gray (Gy)	A measure of exposure; 1 Joule per Kg; 1 gray=100 Rads.
Half-life	The time required for half of the atoms of a particular radioactive substance lose half of its activity. Half-lives range from fractions of a second to billions of years.
Individual monitoring devices	Devices designed to be worn by a single individual for the assessment of dose equivalent. For purposes of this manual, "personnel dosimeter" and "dosimeter" are equivalent terms. Examples of individual monitoring devices are film badges, thermo luminescent dosimeters (TLDs), pocket ionization chambers, and personal air sampling devices.
Internal dose	That portion of the dose equivalent received from radioactive material taken into the body.
Isotope	Atoms with the same atomic number (i.e. the same chemical element) but with different atomic weights.

Leak test	A test performed to detect leakage of a radiation source.
License	A license issued by the Agency in accordance with the rules adopted by the Agency.
Licensed material	Radioactive material received, possessed, used, transferred or disposed of under a general or specific license issued by the Agency.
Licensee	Any person who is licensed by the Agency in accordance with the rules and the Act.
Limits (dose limits)	The permissible upper bounds of radiation doses.
Lost or missing licensed or Registered source of radiation	A licensed or registered source of radiation whose location is unknown. This definition includes licensed or registered source that has been shipped but has not reached its planned destination and whose location cannot be readily traced in the transportation system.
Member of the public	An individual in controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.
Minor	An individual less than 18 years of age.
Monitor	An instrument that measures the level of ionizing radiation in an area.
Monitoring	The measurement of radiation, radioactive material concentrations, surface area activities or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses. For purposes of the manual, "radiation monitoring" and "radiation protection monitoring" are equivalent terms.
Monthly	For surveys and other monthly requirements this shall mean within a 30 day time period.
Non-stochastic effect	A health effect, 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.
Occupational dose	The dose received by an individual in restricted area or in the course of employment in which the individual's assigned duties involve exposure to sources of radiation, whether in the possession of the licensee, registrant, or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the public.

Planned special exposure	An infrequent exposure to radiation, separate from and in addition to the annual occupational dose limits.
Possess	To use, store or work with radioactive sources.
Public dose	The dose received by member of the public from exposure to sources of radiation either within a licensee's or registrant's controlled area or in unrestricted areas. It does not include occupational dose, dose received from background radiation, dose received as a patient from medical practices or dose from voluntary participation in medical research programs.
Quality factor	The modifying factor listed in the table below that is used to derive dose equivalent from absorbed dose:

QUALITY FACTORS AND ABSORBED DOSE EQUIVALENCES

TYPE OF RADIATION	Quality Factor (Q)	Absorbed dose equal to a Unit Dose Equivalent
X, gamma, or beta radiation and high-speed electrons	1	
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge	20	0.05
Neutrons of unknown energy	10	0.1
High-energy protons	10	0.1

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.
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Rad	A unit of absorbed dose of ionizing radiation equal to an energy of 100 ergs per gram of irradiated material.
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 manual, does not include non-ionizing radiation, such as radio or microwaves or visible infrared or ultraviolet light.
Radiation area	An area in which radioactive material or radiation producing machines are used or stored.
Radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.
Radioisotope	A radioactive isotope of an element.
Reference Man	A hypothetical aggregation of human physical and physiological characteristics determined 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. A description of the Reference Man is contained in the international commission on radiological protection report, ICRP publication 23, "Report of the Task Group on Reference Man".
Rem (Roentgen equivalent man)	The unit of dose of any ionizing radiation that produces the same biological effect on human tissue as one roentgen of x-rays.
Respiratory protective equipment	An apparatus, such as a respirator, used to reduce an individual's intake of airborne radioactive materials.
Roentgen	A unit of gamma or x-radiation, which is the amount of radiation that produces one electrostatic unit of charge of either sign in one cubic centimeter of dry air at 0° C and 760mm Hg.
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.
Shallow-dose equivalent	Applies to the external exposure of the skin or an extremity; is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2) averaged over an area of one square

	centimeter.
Sievert (SV)	A measure of exposure; 1 Sievert = 100 rems.
Site boundary	That line, beyond which the land or property is not owned, leased or otherwise controlled by the licensee.
Stochastic effect	A health effect that occurs 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 incidences are examples of stochastic effects. For purposes of this manual, “probabilistic effect” is an equivalent term.
Survey	An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal or presence of sources of radiation. When appropriate, such evaluation includes, but is not limited to, tests, physical examinations and measurements of levels of radiation or concentrations of radioactive materials present.
thermo luminescent dosimeter(TLD) badge	A badge containing a thermo luminescent “chip” which is worn by persons working with or around radioactive materials. When appropriate, such evaluation includes, but is not limited to, tests, physical examinations and measurements of levels of radiation or concentrations of radioactive materials present.
Total effective dose equivalent	The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
Very high radiation area	An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rad in 1 hour at 1 meter from a source of radiation or from any surface that the radiation penetrates.
Visitor	Individuals who routinely do not work or attend classes on the University of Alabama campus.
Week	Seven consecutive days starting on Sunday.
Weighting factor (Wt)	For an organ tissue (T) means 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 dose equivalent, the values of Wt are:

ORGAN DOSE WEIGHTING FACTORS

Organ or Tissue	Wt
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30
Whole Body	1.00

Whole body	For purposes of external exposure, head, trunk (including male gonads), arms above the elbow or legs above the knee.
Working level (WL)	Any combination of short lived radon daughters in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy. The short-lived radon daughters are: 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.
Working level month (WLM)	An exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year equals approximately 170 hours per month).
X-radiation	Short wavelength, ionizing, electromagnetic radiation normally resulting from interaction of energetic electrons with a metal target, as in an x-ray tube. X-rays are similar to gamma rays, but the two are differentiated on the basis of origin.

APPENDIX B ACRONYMS & ABBREVIATIONS

ALARA	as low as reasonably achievable
ALI	annual limit on intake
CHP	Chemical Hygiene Plan
cpm	counts per minute
DAC	derived air concentrations
DCH	Druid City Hospital
dpm	disintegrations per minute
dps	disintegrations per second

ECD	Electron Capture Device
EHS	Office of Environmental Health and Safety
FPM	feet per minute
GFP	gas flow proportional
LSC	Liquid Scintillation Counter
Ci	microcurie
mCi	millicurie
mrem	millirem
NOV	Notice of Violation
NRC	Nuclear Regulatory Commission
NVLAP	National Voluntary Lab Accreditation Program
PEL	permissible exposure limit
PPE	personal protective equipment
RCAC	Radiation Control Advisory Committee
RCRA	Resource Conservation and Recovery Act
RSO	Radiation Safety Officer
RWSA	Radioactive Waste Storage Area
SBRH	State Bureau of Radiological Health
TEDE	Total Effective Dose Equivalent
TLD	Thermo Luminescence Detector
TSCA	Toxic Substances Control Act
UA	University of Alabama

APPENDIX C

Meter Calibration and Efficiency Testing

Meter Calibration Procedure

1. (Exposure Survey Use- sidewall (SW) probe with digital meter readout)
2. Record manufacturer and serial number of meter and probe
3. Determine activity and mR/hr of the 1 Ci Cs 137 calibration source.
4. Place meter and probe on trolley. Record distance from calibration source and calculate mR/hr.
5. Open the shutter of the calibrator. Record meter readout.
6. Adjust meter readout to within +/- 10% of the calculated mR level.
7. Determine readout at three different distances from calibration source.

8. Record information, including date of calibration, calibration source, serial numbers of meter and probe, and efficiency of the meter and probe. Place information into a permanent record.
9. Record information detailed in #6 above onto a label and attach to meter.
10. Range from 2mR/hr through 1R/hr must be measured
11. Energies shall be appropriate for use
12. Meters and corresponding probes (SW) shall be calibrated at 3 month intervals.

Meter Efficiency Testing

(Contamination Survey Use)

1. Record manufacturer and serial number on meter and probe.
2. Determine activity and dpm of calibration source.
3. Place probe on calibration holder above calibration source.
4. Record readout in cpm units.
5. Determine efficiency of meter probe combination for the calibration source used.
$$\text{Cpm/dpm} = \text{efficiency}$$
6. Record information, including date of testing, calibration source, serial numbers of meter and probe, and efficiency of meter and probe. Place information into a permanent record.
7. Record the information detailed in #6 above onto label and attach to meter.
8. Meters and corresponding probes used for contamination surveys shall be calibrated for efficiency at least annually.