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Radiation Safety Manual

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Radiation Safety Manual	
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Applies To:	Employees, students, and others working in UConn laboratories with radioactive materials
Contact:	EHS, Radiation Safety Manager, RSO

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I. INTRODUCTION

A. Purpose

Sources of both ionizing and non-ionizing radiation can be potentially hazardous and therefore must be used in accordance with safety rules and procedures. The rules and procedures in this guide are designed to minimize ionizing radiation exposure to University of Connecticut (UConn) employees, laboratory workers, and the general public as well as to ensure compliance with Federal and State regulations. This program is designed to maintain ionizing radiation exposure to radiation workers and the public as low as is reasonably achievable (ALARA). Hereafter, radioactive material applies to radioactive material that is licensed and regulated by the Nuclear Regulatory Commission (NRC).

B. Responsibilities

Four groups within the University are involved in the radiation protection program:

Radiation Safety Committee (RSC): This is a group of scientists and administrators appointed by the University to establish policies and procedures governing the use of ionizing radiation at UConn. The appointments are made using NRC guidelines.

Radiation Safety: This is an operating unit of the University's Department of Environmental Health and Safety (EHS) consisting of specially trained personnel who are responsible for ensuring compliance with established University policies and procedures regarding radiation safety. The Radiation Safety Officer (RSO) manages this unit.

Licensed Investigators (LIs): University faculty or non-faculty members whose training and experience are such that the Radiation Safety Committee have authorized them to supervise the use of ionizing radiation in their research laboratories. **LIs are responsible for all aspects of their laboratory's radiation safety program.**

Individual Users: Scientists, other professionals, students, research personnel, technical and other workers engaged in laboratory research and research support activities which involve actual use and handling of materials and devices producing ionizing radiation. These Users work under the immediate supervision of an LI.

C. Scope

The policies and procedures contained in this manual apply to all departments, laboratories, and persons using and possessing radioactive material and other ionizing radiation sources on the UConn campuses located at Storrs, Mansfield Depot, Avery Point, Hartford, Stamford, and Waterbury.

D. Policy Statement

According to the University's Health & Safety Policy, "The health and safety of all faculty, staff, students, researchers, contractors and visitors is a principal consideration in the planning and conduct of all University activities and programs, and in the design, construction, modification, or renovation of all University buildings and facilities." The policies and procedures contained in this manual were established by the Radiation Safety Committee and incorporate Federal and State regulations and University specific policies and procedures governing radioactive materials. All requirements and procedures in this manual must be complied with. For the purposes of this manual, "shall" denotes a requirement while "should" means a recommended standard.

E. Enforcement

Violations of this program may result in appropriate disciplinary measures in accordance with University Laws and By-Laws, General Rules of Conduct for All University Employees, applicable collective bargaining agreements, and the UConn Student Conduct Code.

II. PROGRAM ELEMENTS

A. Radiation Safety Committee

The RSC is composed of members who are appointed by the University Administration. The Committee is comprised of, but not limited to, representatives of the varied ionizing radiation research community, in addition to a representative of the University's Administration. The RSO is a voting member of the Committee. Committee members shall be appointed for three-year terms and may be reappointed. The Committee Chairperson and Vice Chairperson shall be elected by a majority of the members of the Committee for three-year terms. The Committee shall meet at least four times each year.

The RSC has jurisdiction over ionizing radiation sources and activities at all UConn campuses except for the Health Center, which has its own operational program.

The RSC ensures that the University is in compliance with radiation safety regulations issued by Federal and State agencies. It establishes policies regarding radiation protection and provides direction and advice to the RSO on matters regarding radiation safety policy. The RSC periodically reviews the ionizing radiation safety programs for radiation sources at the University. Instances of alleged infraction of use and safety procedures are reviewed with the RSO and the responsible individuals. The committee is the ultimate resolution body regarding issues of radiation safety. A detailed list of the RSC members and their contact information can be found on the EHS website.

B. Radiation Safety

Radiation Safety is part of the EHS Department and is the operational arm of the Radiation Safety Committee that manages the radiation safety program at the University. Radiation Safety is responsible for ensuring the University's compliance with Federal and State radiation safety regulations. A detailed list of Radiation Safety responsibilities can be found in Appendix C . A list of Radiation Safety staff and their contact information can be found on the EHS website.

C. Radiation Safety Inspections

Radiation Safety will perform quarterly compliance inspections in all laboratories authorized to use radioactive sources except for those with licenses declared to be inactive by Radiation Safety.

Radiation Safety inspections include a review of radiation surveys, records and procedures specified as conditions of the LI's Protocol. This does not preclude Radiation Safety from increasing inspection frequencies as necessary to assure and document University compliance. The RSO will review all quarterly inspections and notify the LI of any violations.

D. Licensed Investigator (LI)

LIs are issued a radioactive materials usage license by the RSC and are responsible for ensuring that research and other activities involving radiation sources and radioactive material are carried out in a safe manner. A complete listing of LI responsibilities can be found in Appendix D.

E. Individual User

Each individual at UConn who works directly with radioactive materials or ionizing radiation producing equipment is called a radiation User. Radiation Users are responsible for following the protocol approved for their LI's laboratory and following all pertinent University practices and procedures, including successful completion of required training. Users must be at least 18 years of age unless they are employees of the University. The annual occupational dose limits for minors are 10 percent of the annual dose limits specified in Appendix A for adult workers. A listing of radiation safety procedures for radioactive material Users can be found in Appendix E.

III. LICENSING PROCEDURES

A. Application to Become a Licensed Investigator

The person applying for authorization to possess and use licensed radioactive material or a radiation source shall have sufficient training and experience to safely

carry out and supervise the work. This individual is usually a faculty member, although non-faculty individuals may qualify depending on their experience and training. The required Protocol for the Use of Radionuclides Application Form and the Radionuclide Statement of Training Form are available from Radiation Safety or from the Radiation Safety section of the EHS website. When completed, submit to the RSO for subsequent review and routing to the RSC.

B. Permissible Radionuclides

UConn's Type A broad scope license from the U.S. NRC lists the isotopes and possession limits that may be used at UConn. Contact the RSO if you have a question regarding which isotopes are authorized. Radionuclides not listed cannot be acquired or used unless the University applies for and receives a license amendment from the NRC. Authorization must also be obtained from the RSC prior to acquisition, use, or storage of licensed material.

Per NRC regulations (10 CFR 40), thorium and uranium compounds (e.g., thorium acetate, thorium nitrate, uranyl acetate, uranyl nitrate, etc.) are regulated as radioactive source material and are permitted under general license limits for the University. Laboratory personnel intending to purchase or acquire thorium or uranium compounds must report the quantities, location(s), and intended use to the RSO and receive authorization in advance. The RSO is required to include the amounts of thorium and uranium in the overall University inventory to ensure the possession limit will not be exceeded. Failure to contact the RSO prior to ordering or acquiring may result in a violation of regulatory limits. To minimize total quantities, Radiation Safety requires:

1. Contacting the RSO with the compound name and gram weight of the compound prior to ordering, acquiring, or transferring;
2. Purchasing the smallest quantity for the desired application; and
3. Sharing stocks from other researchers (Radiation Safety can provide a list of researchers possessing thorium and uranium compounds upon request).

C. Review and Approval Procedure

Licensed radioactive material shall not be used in or on human beings as stated in the University's NRC license conditions.

To become an LI of a radioactive material use laboratory, the following steps must be taken:

1. Secure either a "Protocol for the Use of Sealed Source or Radiological Devices" or a "Protocol for the Use of Radionuclides" application form, as

applicable, and a Statement of Training form from the Radiation Safety section of the EHS website or from the RSO. These forms must be completed in detail and returned to the RSO. Consult with the RSO prior to completing the forms if you need assistance with the completion of these forms.

2. Contact Radiation Safety and make arrangements to attend an appropriate radiation safety-training program.

New protocols are reviewed by the RSO, circulated to the RSC for review and, when approved, a radioactive materials usage license is signed by the RSO and issued to the LI. Once an approved usage license is issued, the laboratory will be authorized for radioactive materials use by Radiation Safety, and the LI may obtain radioactive materials in accordance with procurement procedures specified in Section VI.A once laboratory personnel have been appropriately trained. The RSC's approval of any protocol will expire 24 months from the date of formal approval. Renewals and amendments can be made on the same protocol form.

IV. RADIOACTIVE MATERIAL USE PROCEDURES

A. Laboratory Procedures

1. General Radiation Protection Requirements and Precautions

a. There shall be no smoking, eating, drinking, applying cosmetics, or storage of food in any radiologically controlled area where there is a potential for sources of radioactive materials to be used, handled, transferred, or stored.

b. Whenever practical, the User should perform a trial experimental run using non-radioactive (or low activity) material to establish the adequacy of procedures and equipment.

c. Before using a radioactive source, radiation levels of the source shall be measured. Handling tongs or a suitable remote-handling device should be used when practical for sources with radiation levels above background.

d. Exhaust ventilation approved by Radiation Safety shall be used when performing operations that might produce airborne contamination (i.e., evaporations, sanding or grinding, transfers of unsealed powdered or volatile radioactive material).

e. Protective gloves and a lab coat shall be worn at all times during operations involving the handling of unsealed radioactive materials.

f. After handling unsealed radioactive material, wash hands before leaving the laboratory.

g. Materials and equipment shall be surveyed before removal from a potentially contaminated area.

A more detailed list of radiation safety guidelines for radioactive materials Users can be found in Appendix E.

2. Security

a. Licensed radioactive material in a laboratory shall be under the constant surveillance and immediate control of an authorized User or secured to prevent unauthorized removal from the laboratory. This includes all radioactive sealed sources, stock solutions, samples, packages, and wastes.

b. Lone access to radiologically controlled areas by unauthorized individuals shall be prevented. Unauthorized, unescorted individuals should be challenged when attempting to gain access to a controlled area.

3. Caution Signs and Labels

a. Each laboratory storing or using radioactive material must be posted with appropriate signs, in conformity with 10 CFR 20.1902 and 10 CFR 20.1903.

b. Each container of radioactive material shall be labeled by the User in conformity with the following procedures, which meet State and Federal regulations:

i. Each container holding radioactive material more than the quantities listed in Appendix C of 10 CFR 20 must have a durable, clearly visible label bearing the radiation caution symbol and the words “CAUTION RADIOACTIVE MATERIAL” or “DANGER RADIOACTIVE MATERIAL.” NRC regulation in 10 CFR 20.1901 specifies color and design.

ii. These labels also must state the quantities and kinds of radioactive materials in the containers and date of measurements of quantities. (Appropriate labeling tape is available through Radiation Safety in limited quantities.)

iii. Laboratory containers such as beakers, flasks and test tubes used transiently in the laboratory procedures **shall be appropriately labeled**.

4. Work Surfaces

All work areas (bench tops, hoods, floors, etc.) as well as storage areas adjacent to permanent setups and sinks should be covered at all times with stainless steel or plastic trays, or other impervious materials to prevent radioactive contamination of porous surfaces. For some purposes, a plastic backed absorbent paper will be satisfactory. If absorbent bench paper is used, then it should be discarded frequently to prevent spread of contamination.

B. Decontamination Procedures

1. General

Decontamination of an area or piece of equipment must commence as soon as the contamination is witnessed or discovered as specified in Section V.A., following protocols summarized below in Section B.3. Procedures for decontamination are contingent upon the extent of contamination as follows:

a. Contamination that occurs during the routine course of work or results from a minor spill and is readily contained on a work tray or absorbed by bench paper should be addressed by the responsible trained radioactive material User(s). The User(s) handling the decontamination should notify their LI of such spills and the results of decontamination attempts.

b. For incidents that involve contamination of the floor, contamination outside the controlled area, or personal contamination, refer to Section B.2 and notify the LI and Radiation Safety immediately. The individual User(s) responsible for the contamination will perform the clean-up under the supervision of Radiation Safety. The area or equipment will be considered contaminated until proven otherwise.

2. Radioactive Spill or Incident

A radioactive spill or contamination incident requiring immediate assistance or involving personal injury, personal contamination, or contamination outside a controlled area shall be considered an emergency. Emergency procedures specified in Appendix I and After-Hours Emergency Procedures specified in Appendix J must be followed in addition to the procedures specified in the LI's protocol.

3. Decontamination

Trained radiation workers should use the spill kit provided by Radiation Safety and implement the following procedures when cleaning up radioactive contamination or minor spills:

a. Wear proper protective clothing while cleaning, including gloves, lab coat, shoe covers if needed, etc.

b. Use “Count-off”, “Rad-Con” decontaminant, “Radiacwash”, “Simple Green”, or other appropriate cleanser.

c. Work from the outside of the contaminated area toward the center being careful to pick the contamination up on the cleaning towel and not spread the contamination around. Clean and re-survey until final wipe test contamination levels are below 100dpm per 100cm^2.

d. If decontamination attempts are unsuccessful, leave the spill area in a safe condition, contact Radiation Safety, and label the area(s) with appropriate warning signs and labels.

C. Aerosols, Dusts and Gaseous Products

1. General

Procedures involving aerosols, dusts or gaseous products or procedures that might produce airborne contamination shall be approved in advance by the Radiation Safety Committee and conducted in a Radiation Safety approved hood, glove box or other suitable closed system. All releases from such systems shall not exceed the maximum permissibly concentration in air for the radionuclide in question. See Appendix B (Table 2) of 10 CFR 20 for appropriate values. However, where practical, traps should be incorporated in the experiment setup to ensure that environmental releases are as small as possible. Radioactive gases or materials with radioactive gaseous daughters must be stored in gas-tight containers and must be kept in areas having approved ventilation. Hoods used for volatile radionuclide work must be tested by Radiation Safety to ensure that they meet the minimum requirements for air velocity at the face of the hood.

2. Iodine Vapors

Procedures in which volatile radioiodine vapors may be generated shall be approved in advance by the Radiation Safety Committee and conducted in a Radiation Safety approved glove box or radionuclide hood with adequate flow rate and charcoal filters. Advice must be sought from Radiation Safety before conducting experiments with radioiodine and the facilities must be evaluated for containment purposes.

D. Storage of Radioactive Material

The storage of radioactive material in the laboratories shall comply with the following:

a. Radioactive material shall be kept or stored in a secure location in a manner that will provide minimum exposure to personnel.

b. Suitable storage precautions shall be taken against fire, explosion, and flooding, or unauthorized removal.

The storage of radioactive material by Radiation Safety shall comply with the following:

a. Active License – Radiation Safety may store radioactive material that is only used on rare occasions. This material will be stored on a temporary basis for up to a maximum period of two years.

b. Inactive License – all radioactive material will be stored for a maximum period of two years.

c. License Termination – all radioactive material will be disposed of or transferred to another LI at the discretion of the RSO.

E. Generally Licensed Radioactive Material Contained in Equipment

All equipment which contains radioactive materials regulated by the general license issued under 10 CFR 31.5 (ECDs within Gas Chromatographs, Liquid Scintillation Counters, etc.) shall be registered with Radiation Safety. This equipment shall be labeled with a "Caution Radioactive Material" sign or other label approved by Radiation Safety. The sources shall be leak tested if required by the provisions of the general license. Radiation Safety shall be notified each time the source or equipment containing the source is to be moved or disposed of.

F. Demonstrations Using Radiation

Radioactive materials or other radiation sources may be used in demonstrations for students as long as all practical measures are taken to minimize radiation exposure to both the demonstrator and the students present. Students should be informed of the risks or lack of risk before the demonstration begins. Students under the age of 18 (minors) and the general public are limited to 100 mrem per year per 10 CFR 20.1301. Consult with the RSO during the planning stages of the demonstration.

G. Visitors in Radionuclide Laboratories

LIs shall restrict casual traffic through laboratory areas where radioactive materials are used. Untrained visitors must be escorted at all times by a radiation safety trained member of the authorized LI's laboratory. Authorized Users should take extra

precautions to ensure the safety of visitors. See Appendix H for the complete University of Connecticut Visitor Policy.

H. Training of Laboratory Personnel

University policy requires that each individual working in a radioactive material-controlled area be given information on possible radiation hazards, biological effects of radiation, and methods of radiation protection. Radiation Safety assists the LIs by providing routine initial radiation safety training sessions for both radioactive material Users and Non-Users in the laboratory. When new individuals join the laboratory, even on a temporary basis, the LIs must ensure the new Non-Users or Users arrange for their attendance at one of the training sessions provided by Radiation Safety. **Both radioactive materials Users and Non-Users in the laboratory shall complete the initial training prior to working in the laboratory.**

The LI must also provide new laboratory Users and Non-Users with on-the-job, laboratory specific training related to radiation safety. The LI shall document the lab-based training on the "Laboratory Based Training Form" found on the Radiation Safety section of the EHS website.

Refresher training is offered by Radiation Safety personnel on an annual basis. Refresher training is required for Users biennially. Sessions are arranged in conjunction with the LI's Protocol renewal date and conducted at their laboratory or online.

Researchers intending to use uranium or thorium compounds must consult with the RSO prior to acquisition or use to obtain authorization for intended procedures and must complete a Radiation Safety training program specifically for proper handling and management of these compounds.

V. SURVEYS AND MONITORING

A. Post-Operational Surveys

Users shall conduct an appropriate contamination survey after each period of use or handling of unsealed radioactive material prior to physically departing the controlled area and no longer attending the designated radioactive materials utilization area. This post-operational survey must include: (i) all areas in proximity to where the radioactive material was used, including work surfaces, floor, and all equipment; and (ii) personal monitoring, including protective clothing and equipment, personal clothing, and shoes. Survey protocols depend on the type of radionuclide used as follows:

1. **All beta and gamma radiation emitters excluding Tritium (H-3)**
   A meter survey using an approved detector shall be performed following each procedure when radioactive material is used or handled and documented on either the "Radioactive Material Use Log Form - Single Survey" or "Radioactive Material Use Log Form - Multiple Survey" forms. If the meter survey reveals radiation levels above background, the affected area shall be decontaminated, as detailed in Section IV.B., and a final wipe test shall be taken to ensure that all surveyed areas are below the contamination limit of 100dpm per 100cm^2. The wipe tests shall be counted in the appropriate equipment, either a liquid scintillation counter (LSC) or gamma counter and documented on the appropriate "Radioactive Material Use Log Form" with the wipe test locations and results attached.

2. **Tritium (H-3)**
   A contamination wipe test survey shall be performed in lieu of the meter survey following each procedure. The post-operational wipe tests shall be counted in a liquid scintillation counter (LSC) and documented on either the "Radioactive Material Use Log Form - Single Survey" or "Radioactive Material Use Log Form - Multiple Survey" forms with the wipe test locations and results attached.

For wipe test surveys of any radionuclide, results in excess of the University's removable contamination limit of 100dpm per 100cm^2 shall be considered contaminated and immediately decontaminated and re-surveyed until compliance with the wipe test limit is achieved. For any contamination over this limit, the LI shall be notified of the contamination and the results of the decontamination.

Radiation Safety shall be notified immediately to ensure proper decontamination procedures if detected contamination meets either of the following criteria: (i) Any contamination, regardless of magnitude, which involves the floor, personal contamination, or falls outside of the controlled area. (ii) Any contamination levels in excess of 10,000dpm per 100cm^2, even if the contamination is confined to a radioactive material work area on a benchtop, tray, or absorbent material, or occurs on equipment or instrumentation designated for radioactive material use.

Each laboratory using radioactive materials must provide the appropriate radiation detection instruments to enable personnel to conduct routine surveys for radiation exposure and surface contamination. Radiation Safety should be consulted regarding the purchase of a survey instrument to ensure it is adequate.

Radiation survey meters used for dose rate measurements and post-operational contamination surveys shall be calibrated annually in accordance with appropriate American National Standards Institute (ANSI) standards and manufacturer

specifications. Radiation Safety, or an approved calibration facility, will perform the calibrations. All instruments will be calibrated to read within 20% of full scale and any appropriate correction factors will be attached to the instruments or kept on file at Radiation Safety. Survey instruments that are malfunctioning, are in need of repair, or not calibrated, shall be tagged "out of service" or similar wording and shall not be brought back into service until they are repaired and re-calibrated. It is the LI's responsibility to provide funding for any necessary repairs, replacements parts, or equipment. Radiation Safety will provide the laboratory with a replacement survey meter to use while their meter is being calibrated or on a temporary basis if needed. Spare replacement batteries should be kept in the LI laboratory. Radiation Safety can provide batteries if needed.

B. Personnel Monitoring

During work with unsealed radioactive material other than H-3, an approved survey meter shall be on and running in the immediate vicinity of the controlled work area. Throughout the entire procedure, the User shall intermittently survey the following: (i) protective clothing, including lab coat and gloves; (ii) any exposed personal clothing, including shoes; and (iii) any work surfaces or equipment (e.g., pipettes) that are frequently exposed to radioactive material. If contamination is detected on disposable gloves, they shall be changed immediately. If contamination is found on the lab coat, it shall be removed and discarded in the appropriate radioactive waste container.

Except for individuals using soft beta emitters (max. energy <0.2 MeV) or pure alpha emitters, individuals directly involved with radioactive materials, or ionizing radiation producing equipment at University facilities may be required to have and wear a radiation monitoring badge when working. Request forms for radiation monitoring badges can be obtained from Radiation Safety. Individuals leaving the University or who no longer require the badge should complete and submit a "Dosimeter Badge Discontinuance Form" which can be found on the Radiation Safety section of the EHS website.

Ring badges are required when handling more than 1.0 mCi of P-32 and in other situations where the hand exposures may be significant. Ring badges shall also be requested from Radiation Safety when needed.

The RSO will follow-up on any significant or unusual badge exposures to determine the cause of the exposure and whether there is a need to make changes to avoid future exposures.

Individuals issued personnel radiation monitoring devices shall be furnished a copy of their annual exposure report under the provisions of the NRC regulation 10 CFR 19.13. Exposure records are on permanent file at Radiation Safety.

C. Bioassays

Appropriate bioassays are required if there is a potential for an adult individual to receive an intake in excess of >10% of the applicable radiation exposure Annual Limit on Intake (ALI) values in 10 CFR 20 Appendix B (Table 1, Columns 1 and 2) either from an accident or normal operations. These tests should be arranged through Radiation Safety.

1. Beta and Gamma Emitters

Individuals working with unsealed beta or gamma emitters in amounts greater than 10 millicuries per day will be required to submit urine samples for analysis. The samples should be a baseline sample prior to use and a sample submitted at least 24 hours after a single experiment. For continuing experiments, samples may be required at weekly intervals. The RSO reserves the right to require bioassays after accidents and operational procedures where significant uptakes (>10%ALI) could occur.

2. Iodinations

Individuals performing iodinations shall have thyroid counts on a frequency established by Radiation Safety. A baseline thyroid count will be performed by the RSO or Radiation Safety staff prior to an iodination and a post iodination thyroid count between one and seven days later.

3. Internal Dose Calculations

The RSO will calculate significant internal organ doses based on bioassay data and currently accepted dose models. An outside health physics expert consultant specializing in internal dose calculations may be utilized to make independent dose calculations for any internal doses that exceed 10% of the appropriate annual occupational dose limits specified in Appendix A.

D. Leak Testing of Sealed Sources

1. Sealed sources and detector cells containing beta or gamma emitters greater than 100 microcuries shall be tested for leakage and contamination at intervals not to exceed 6 months.

2. Sealed sources designed to emit alpha particles and have activities exceeding 10 microcuries shall be tested for leakage and contamination at intervals not to exceed 3 months.

3. Sealed sources and detector cells need not be leak tested if they contain only H-3, they contain only a gas, the half-life of the nuclide is 30 days or less, or they are being held in storage and not used.

4. Sealed sources that are in storage and not being used must be leak tested at a minimum of every ten years.

5. Radiation Safety is responsible for conducting the leak tests.

E. Radiation Safety Inspections

Radiation Safety will perform quarterly compliance inspections of all LI laboratories that are authorized to work with unsealed radioactive material with the exception of licenses declared to be inactive by Radiation Safety. These inspections include a review of radiation surveys, records and procedures specified as conditions of LI's Protocol, as well as a meter survey and contamination survey of the laboratory. This does not preclude Radiation Safety from increasing inspection frequencies as necessary to assure and document University compliance. The RSO will review all quarterly inspections and notify the LI of any violation(s). A list of compliance actions is included in Appendix K.

VI. PROCUREMENT, ACQUISITION, AND TRANSFER OF RADIONUCLIDES

Only LIs or other radioactive material Users authorized by the RSO in advance are permitted to order, acquire (e.g., obtain from another institution), or transfer licensed radioactive material to or from another LI or institution.

A. Procedures for Acquisition or Transfer

If any form of radioactive material is intended to be acquired or transferred from another licensee or individual, the RSO must be contacted for authorization prior to acquisition. The RSO must ensure the University's possession of the intended radionuclide and amount of radioactivity are within NRC license requirements, other State and Federal regulatory requirements, and UConn policy to do so. Licensed radioactive material will require authorization from the RSC through the protocol application process. If the radioactive material requested is an exempt quantity or generally licensed sealed source the information on the "Registration for Exempt and Generally Licensed Sealed Sources" form must be provided to the RSO.

B. Procedures for Procurement

Prior to placing an order from a vendor for any form of radioactive material in the University's purchasing system, an authorized individual must:

1. Receive pre-requisite training from the Radiation Safety Officer or designee on the proper procedures for procurement of radioactive material in the University's purchasing system.

2. Ensure other authorized Users who will be allowed to place radioactive material orders receive the pre-requisite training from Radiation Safety.

Once authorization and the required training are completed, radioactive material orders may be initiated in the University's purchasing system by using the "EHS Purchase Approval" requisition form button and utilizing the appropriate code in accordance with the procedures specified in the pre-requisite training. Instructions and the list of the EHS restricted materials codes can also be found on the EHS website for reference.

Please keep the following in mind when initiating radionuclide orders:

1. Be sure that your licensed quantity will not be exceeded. If your balance needs to be updated, contact the RSO before you place the order.

2. If radioactive material is acquired by a licensed facility (e.g., a reactor facility) that is outside of the University's purchasing system, the LI must obtain prior approval from the RSO before ordering or acquiring the radioactive material. The LI must obtain the current *Radioactive Material Requisition Form* from the RSO and complete and submit it to the RSO via email to initiate the approval process.

3. All required information on the radioactive material order portion of the online requisition form in the purchasing system or form, as applicable, must be completed prior to submitting the requisition.

4. Approvals for radioactive materials are made through Radiation Safety, NOT PURCHASING. The Radioactive Material Requisition completed in the purchasing system is routed to Radiation Safety for approval. **Orders must be placed well in advance of expected delivery to allow sufficient time for approval and processing by Radiation Safety and other University departments.**

5. Orders may be delayed or disapproved if discrepancies or errors are identified by Radiation Safety.

6. Radioactive orders must **NOT** be placed with the University P-Card or other credit card.

C. Delivery of Radionuclides

1. Packages Received During Normal Working Hours

The package will be delivered to Radiation Safety where it will be monitored in accordance with DOT and NRC regulations and added to the appropriate LI inventory. Radiation Safety will deliver the package to the LI. The required procedure for receiving and opening radioactive shipments should be followed (see Appendix F).

2. Packages Received After Normal Working Hours and on Non-Working Days

Any packages containing radioactive material that arrive between 4:00 PM and 8:00 AM, or on a non-working day, will not be accepted unless special arrangements are made with the RSO.

D. Transfer of Radionuclides

1. If an LI wishes to transfer radionuclides to another LI within the same campus, they shall:

    a. Notify the RSO and request permission for the transfer prior to any transfer.

    b. Ensure that the amount and radionuclide being transferred is consistent with the receiving laboratory's license.

2. LIs and Users are not permitted to transport or transfer radioactive materials from their authorized, designated laboratory to other locations. **No radioactive material may be transferred to or from UConn, used on another campus, or outside of UConn except as provided in the University's NRC license**. **If an LI wishes to receive or transfer radioactive material from another institution or another campus, the RSO shall be contacted prior to such intended transfers and uses.** If permitted by the RSO, all radioactive material transported off of the University property shall be packaged in accordance with U.S. Department of Transportation or IATA regulations only by trained individuals in EHS Radiation Safety. Radiation Safety staff must prepare all packages for off-site shipment and arrange for shipping of radioactive material packages to ensure compliance with regulations.

VII. RADIOACTIVE WASTE DISPOSAL

Radioactive waste must be managed in a safe and economical fashion consistent with State and Federal regulations. Each laboratory must segregate, monitor, store, and document any waste produced.

Radiation Safety is responsible for collecting radioactive waste from each laboratory, performing any processing of the waste, and arranging for its ultimate disposal. Specific procedures for proper disposal of radioactive waste by LI laboratory Users and handling radioactive waste can be found in Appendix G.

VIII. DECOMMISSIONING

A. Release of Equipment from Radiation Control

Equipment and materials that have been used or contaminated with radioactive material shall only be released from radiation control for unrestricted use by Radiation Safety. Radiation Safety will survey and release the equipment for unrestricted use if there is no fixed or removable radioactivity distinguishable from background radiation. Contact Radiation Safety to free release radioactive labeled designated equipment prior to repair, transfer, or disposal. Radiation Safety will remove all radioactive signs and postings following successful release from radiation control.

B. Release of Radioactive Material Laboratories and Facilities from Radiation Control

A radiation laboratory or facility can only be released from radiation control after it has been thoroughly surveyed for external radiation and contamination by Radiation Safety and found to be free of any significant radiation (external radiation levels indistinguishable from background and contamination levels less than 100dpm per $100cm^2$). Radiation Safety will remove all radioactive signs and postings following successful release from radiation control.

C. Release of Buildings from Radiation Control

Buildings containing or formerly containing radioactive materials laboratories or facilities can only be released from radiation control (decommissioned) after a survey has been performed in accordance with acceptable NRC regulatory guidance criteria and regulations in 10 CFR 20 Subpart E pertaining to the decommissioning of facilities. NRC's NUREG-1757 "Consolidated Decommissioning Guidance" is considered an acceptable guidance document. The release of buildings must meet the release criteria for both the NRC and the State of CT Department of Energy and Environmental Protection (DEEP).

IX. DEFINITIONS

Absorbed Dose (Gy): The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest. The units of absorbed dose are the rad and the gray.

Active: A Licensed Investigator who has a current protocol approved by the Radiation Safety Committee and is authorized to use and store radioactive material. The active LI laboratories are set-up for radionuclide use and are inspected on a routine basis by Radiation Safety. The LI must ensure that all radionuclide laboratories under their control are complying with all applicable regulations.

Activity (Radioactivity): The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the Becquerel (Bq).

Airborne Radioactive Area: A room, enclosure or area in which airborne radioactive materials, composed wholly or partly of licensed material in excess of the derived air concentrations specified in Appendix B to 10 CFR 20 or to such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

ALARA (As Low As is Reasonably Achievable): 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 activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Annual Limit on Intake (ALI): means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rem (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table 1, Columns 1 and 2, of Appendix B to 10 CFR 20.

Authorized User: Refers to someone who has been designated by an LI as qualified by virtue of their training and experience to use radioactive material or radiation producing equipment in the LI's Laboratory.

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

does not include radiation from source, byproduct, or special nuclear materials regulated by the Commission.

Becquerel (Bq): An SI unit of activity, one Becquerel equals one nuclear transformation per second.

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

Byproduct material: (1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or using special nuclear material; (2) The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition; (3)(i) Any discrete source of radium-226 that is produced, extracted, or converted after extraction, before, on, or after August 8, 2005, for use for a commercial, medical, or research activity; or (ii) Any material that (A) Has been made radioactive by use of a particle accelerator; and (B) Is produced, extracted, or converted after extraction, before, on, or after August 8, 2005, for use for a commercial, medical, or research activity; and (4) Any discrete source of naturally occurring radioactive material, other than source material, that—(i) The Commission, in consultation with the Administrator of the Environmental Protection Agency, the Secretary of Energy, the Secretary of Homeland Security, and the head of any other appropriate Federal agency, determines would pose a threat similar to the threat posed by a discrete source of radium-226 to the public health and safety or the common defense and security; and (ii) Before, on, or after August 8, 2005, is extracted or converted after extraction for use in a commercial, medical, or research activity.

Commission: The U.S. Nuclear Regulatory Commission or its duly authorized representatives.

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

Committed Effective Dose Equivalent (CEDE) ($H_{E,50}$): The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated (W_T) and the committed dose equivalent (H_T)to these organs or tissues ($H_{E,50} = \Sigma W_T H_{T,50}$).

Controlled Area: An authorized, designated, limited-access area in which the occupational exposure of personnel to radiation or to radioactive material is under the supervision of an LI or Radiation Safety. Access, occupancy, and working conditions are controlled for radiation protection purposes.

Curie (Ci): A non-SI unit of radioactivity. One curie equals 3.7 x 10^{10} disintegrations per second (1 Ci = 3.7 x 10^{10} Bq = 37 GBq). 1mCi=0.001 Ci, 1 µCi = 0.000001 Ci.

Declared Pregnant Woman (DPW): A woman who is an occupational radiation worker and has voluntarily informed the University's RSO, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

Decommissioned: An LI who has permanently suspended their use of radioactive material. Decommissioned LI laboratories and equipment are free-released for unrestricted use. Radiation Safety collects and stores the archive radiation safety records from the LI.

Deep-Dose Equivalent (DDE): The external whole-body exposure dose equivalent at a tissue depth of 1 cm (1000 mg per cm^2).

Delayed Effects: Somatic effects such as cancer that may occur years after exposure to radiation.

Dose or Radiation Dose: A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent or total effective dose equivalent as defined in other paragraphs of this section.

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

***Effective Dose Equivalent (EDE) (H_E)*:** The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma W_T H_T$).

***Effective Dose Equivalent for External Radiation Exposures (EDEX)**:* The sum of the EDE for external exposures. EDEX is a quantity to be determined and recorded when monitoring external dose. The December 4, 2007, rule replaced the DDE with the EDEX. EDEX=$\sum W_C$ DDE_C. The measured DDE for each compartment (DDE_C) is weighted with the associated "compartment factor" (W_C) as listed in Table 1 of NRC Regulatory Guide 8.40. The resulting weighted doses are then summed to determine the EDEX for the whole body.

Embryo or Fetus: The developing human organism from conception until the time of birth.

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

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

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

Extremity: Hand, elbow, arm below the elbow, foot, knee, or leg below the knee.

Genetic Effects: Abnormalities that may occur in the future children of exposed individuals and in subsequent generations.

Gray (Gy): The SI unit of absorbed dose in any medium. One Gray is equal to 100 rads.

Half-Life ($t_{½}$): The time required for half the atoms of a particular radioisotope to decay.

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

Inactive: An LI who has temporarily suspended their use of radioactive material (generally one year or more). Inactive LI laboratories and equipment are free-released for unrestricted use. The approved protocol is maintained on file with Radiation Safety. If the LI re-activates, the laboratory is set-up for radionuclide use and training of LI laboratory workers must be current prior to resuming radioactive material use.

Individual: Any human being.

Individual Monitoring: The assessment of dose equivalent by the use of devices designed to be worn by an individual, the assessment of committed effective dose equivalent by bioassay or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours or the assessment of dose equivalent by the use of survey data.

Individual Monitoring Devices (Individual Monitoring Equipment): Devices designed to be worn by a single individual for the assessment of dose equivalent such as personnel monitoring badges, pocket dosimeters, and personal ("lapel") air sampling devices.

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

Ionizing Radiation: A form of radiation, which includes alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions.

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

License: A license issued under the regulation in 10 CFR parts 30 through 36,39,40,50,60,61,70 or 72.

Licensed Investigator (LI): A faculty or non-faculty member who has been permitted by the Radiation Safety Committee, by virtue of their experience and training, to possess and use radioactive materials at UConn.

Licensed Material: Source material, special nuclear material or by-product material received, possessed, used, transferred, or disposed of under a general or specific license issued by the Commission.

Licensee: The holder of an NRC license; The University of Connecticut (UConn).

License Termination: All radioactive material is permanently transferred to Radiation Safety, waste is disposed of, and laboratories are decontaminated and released for unrestricted use. All records related to the laboratory's radiation safety program would be collected and archived by Radiation Safety. LIs must submit a new protocol for approval by the Radiation Safety Committee when they wish to start using radioactive material again.

Limits (Dose Limits): The permissible upper bounds of radiation doses.

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

Member of the Public: An individual who is not an authorized trained radioactive material User in a controlled or unrestricted area. Any individual except when that individual is receiving an occupational dose.

Minor: An individual less than 18 years of age.

Mixed Waste: Waste which contains both hazardous waste which is regulated under the Resource Conservation and Recovery Act (RCRA) and source, special nuclear, or by-product radioactive material. It is jointly regulated by NRC or NRC's Agreement States and EPA or EPA's RCRA Authorized States.

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

Nonstochastic (Deterministic) Effect: Health effects of radiation exposure, 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.

Non-User: An individual who is authorized to have unescorted access to a controlled or restricted area(s) but is not authorized to work with radiation sources.

NRC: The U.S. Nuclear Regulatory Commission or its duly authorized representatives.

Occupational Dose: means the dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the public.

Public Dose: The dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation from either a licensee’s controlled area or in unrestricted areas. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under 10 CFR 35.75, or from voluntary participation in medical research programs.

Quality Factor (Q): The factor by which the absorbed dose (rad or gray) is to be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or sievert) to an exposed individual. It is used because some types of radiation, such as alpha particles, are more biologically damaging internally than other types. The quality factors used to derive dose equivalent from absorbed dose are listed in tables 1004(b).1 and 1004(b).2 of 10 CFR 20.1004.

Rad: A unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joule per kilogram. 1 rad = 0.01 gray.

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

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

Radiation Worker: See Authorized User.

Radioactive Material: Any material that emits ionizing radiation. The University reserves the right to control all such material whether exempted from Federal regulation or not.

Radioactivity: See Activity

Rem: One of the two standard units used to measure the dose equivalent (or effective dose), which combines the amount of energy (from any type of ionizing radiation that is deposited in human tissue), along with the medical effects of the given type of radiation. The dose equivalent in rem is equal to the absorbed dose in rads multiplied by the quality factor (Q).

Respiratory Protective Device: An apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

Restricted Area: An area with access limited by the University for the purpose of protecting individuals against undue risk from exposure to radiation and radioactive materials. Restricted areas do not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Roentgen (R): The quantity of x- or gamma radiations that produce ions carrying a charge of 2.58×10^{-4} coulombs per kilogram of air at 0 degrees C and 760 mm Hg.

Sanitary Sewerage: A system of public sewers for carrying off wastewater and refuse, but excluding sewage treatment facilities, septic tanks and leach fields owned or operated by the University.

Shallow-Dose Equivalent (SDE) (H_s): which applies to the external exposure of the skin of the whole body or the skin of an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg per cm^2).

Somatic Effects: Effects occurring in the exposed individual.

Sievert: The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in Sieverts is equal to the absorbed dose in grays multiplied by the quality factor (Q) (1 Sv = 100 rem).

Site Boundary: The line beyond which the land or property is not owned, leased, or otherwise controlled by the University.

Source Material: Uranium or thorium or any combination of uranium and thorium in any physical or chemical form or ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more of uranium, thorium or any combination of uranium and thorium. Source material does not include special nuclear material.

Special Nuclear Material: Plutonium, uranium-233, uranium enriched in the isotope 233 or isotope 235 or any material artificially enriched by any of the foregoing but does not include source material.

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

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

Total Effective Dose Equivalent (TEDE): In accordance with a December 4, 2007 rule and subsequent change to NRC regulation, summarized in Regulatory Guide 8.7, Revision 4,

TEDE was redefined as the sum of the effective dose equivalent for external exposures (EDEX) and the committed effective dose equivalent for internal exposures (CEDE).

Total Organ Dose Equivalent **(TODE):** The term is included in the revised NRC Forms 4 and 5 to denote the sum of the DDE and the CDE to the organ receiving the highest dose, to be consistent with the regulations described in 10 CFR 20.2106(a)(6).

Transport Index (TI): The dimensionless number (rounded up to the first decimal place, i.e., tenths) placed on the label of a radioactive material package to designate the degree of control to be exercised by the carrier during transportation. The TI of the package must be indicated in the rectangular TI block in the lower half of the Category II and III Yellow radioactive labels.

Unrestricted Area: An area access to which is neither limited nor controlled by the University.

User: An individual authorized by the LI to work with radioactive material.

Visitor: An individual who is not an authorized radiation safety trained individual and does not have unescorted access to controlled or restricted areas.

Whole Body: The head, trunk (including male gonads), arms above the elbow, or legs above the knee for purposes of external exposure.

Year: The period of time beginning in January used to determine compliance with the provisions of federal and state regulations.

X. APPENDICES

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APPENDIX A: Radiation Exposure Limits

A. Occupational Dose Limits for Adults

The following are State of CT dose limits and federal NRC regulatory dose limits in accordance with 10 CFR 20.1201. These limits are well below the doses that would result in any immediate biological effects but may result in a very small increase in cancer risk to the individual exposed. It is the University's policy to maintain all occupational doses as low as is reasonably achievable (ALARA). The ALARA program is detailed in Appendix B.

	NRC Dose Equivalent (rem per yr)	State of CT DEEP Dose Equivalent (rem per qtr)
Whole Body Dose (TEDE)	5.0	1.25*
Individual Organs (DDE+CDE)	50	1.25*
Skin of Whole Body (SDE)	50	7.5
Extremities (SDE)	50	18.75
Lens of Eye (LDE)	15	1.25*
Declared Pregnant Woman (see below)	0.5 per whole body dose per term	
Environmental Release	(See 10 CFR 20 Appendix B)	

*CT DEEP regulations Sec. 19-24-5 Maximum doses: "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk or lens of eye.

The 10 CFR 20.1301 whole body dose limits for the general public are 100 mrem per year and 2.0 mrem in any one hour.

Pregnant Workers

The Nuclear Regulatory Guides 8.13 "Instruction Concerning Prenatal Radiation Exposure" and Regulatory Guide 8.29 "Instruction Concerning Risks from Occupational Radiation Exposure" should be reviewed by a pregnant employee. The Radiation Safety Officer can also be consulted with to provide further information regarding the risk of fetal exposure to ionizing radiation. If after review of all the information, the occupational worker chooses to declare her pregnancy, she should inform the University through the RSO, and provide signed declaration of said pregnancy.

A declared pregnant woman (DPW), is defined in 10 CFR 20.1003 as a woman who is an occupational radiation worker and has voluntarily informed the University's RSO, in writing, of her pregnancy and the estimated date of conception. The DPW may, if warranted as

determined by the RSO, be monitored monthly with a designated fetal monitor. The assigned fetal monitor is to be worn in or around the abdominal area. This dosimeter is to be worn in addition to her already-assigned personal whole body monitoring badge and be exchanged promptly at the designated time and date. Both the fetal and personal dosimeters are intended only for beta or gamma emitters (other than soft beta emitters) during the pregnancy.

In addition, upon receipt of the pregnancy declaration, the RSO will perform a historical review of the DPW's dose history prior to pregnancy. Dependent upon the type of work involved, and the results of the historical dose review, the RSO may initiate warranted changes to the DPW's official roles and responsibilities. These changes may also be put into effect at any time during the declared pregnancy if the reported monthly fetal dose exceeds the designated ALARA I level for DPWs. These official responsibility changes will remain in effect throughout the remainder of the pregnancy term.

Unofficial radiation dose-related job responsibility changes, mutually agreed upon and arranged between the DPW and her supervisor(s), are not recognized nor sanctioned by the RSO and The University of Connecticut. Such arrangements are considered to be matters of convenience and are therefore non-binding (i.e., such arrangements may be changed or revoked without DPW recourse relating to a personally-determined radiation safety issue or concern, as this determination has already been established by the RSO).

In conclusion, the RSO will take steps necessary to ensure compliance with 10 CFR 20.1208. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

APPENDIX B: ALARA Program for Occupational Radiation Exposures and Radioactive Gaseous and Liquid Effluents

A. Management Commitment

The NRC license activities and commitments, including the ALARA program, are administered and overseen by an executive management representative appointed by the University. The University's executive administration, including the executive management representative for the NRC license, are collectively referred to as "the University's management" in this program.

1. The management of the University of Connecticut is committed to the program described in this document for keeping exposures (individual and collective) and radioactive effluents as low as is reasonably achievable (ALARA). This commitment describes an administrative organization for radiation safety policy, procedures, and instructions to foster the ALARA concept within our institution. The organization will include a radiation safety committee (RSC) and a radiation safety officer (RSO). The University's executive management representative for the NRC license is an ex officio member of the RSC.

2. The University's management, through the RSC, will perform a formal annual review of the radiation safety program including ALARA considerations. This will include reviews of operating procedures and past exposure records, reviews of air and sewer releases of radioactive materials, and consultations with the RSO or outside consultants.

3. Modifications to operating maintenance procedures and to equipment and facilities will be made if they will significantly reduce exposures or effluent releases unless the cost, in our judgement, is considered to be unjustified.

4. In addition to maintaining doses to occupationally exposed individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals will also be maintained at the lowest practicable level.

B. Radiation Safety Committee (RSC)

1. Review of Proposed Licensed Investigators

    a. The RSC will thoroughly review the qualifications of each licensed investigator, with respect to the training and experience for the use which that person has applied and will inform that applicant, through the licensing process, that all exposures to radiation and that all radioactive gaseous and liquid effluents must be maintained ALARA.

b. During the annual review, the RSC will review the ALARA program.

c. The RSC will ensure that all use of byproduct material is justified and proper, and that doses (individual and collective) and radioactive effluent concentrations will be kept ALARA.

2. Delegation of Authority

The judicious delegation of RSC authority is essential to the enforcement of an ALARA program.

a. The RSC will delegate authority to the RSO for enforcement of the ALARA concept.

b. The RSC will support the RSO in those instances in which it is necessary for the RSO to assert authority. When the RSO has been overruled, the RSC will record the basis for its action in the minutes of its quarterly meeting.

3. Review of ALARA Program

a. The RSC will encourage all investigators, through the license review process, to develop procedures, as appropriate, to implement the ALARA concept.

b. The RSC will receive and evaluate a quarterly review of occupational radiation exposures provided by the RSO with particular attention to instances in which Investigational Levels in Table A-1 are exceeded. The RSC will receive and evaluate a semiannual review of releases to air and the sanitary sewer system provided by the RSO paying particular attention to instances in which the investigation levels provided in Table A-2 are exceeded. The principal purpose of this review is to assess trends in occupational exposure and effluent releases as an indicator of the ALARA program quality and to decide if action is warranted when Investigational Levels are exceeded.

C. Radiation Safety Officer (RSO)

1. Annual and Quarterly Review

a. The RSO will perform an annual review of the radiation safety program for adherence to ALARA concepts and make a report to the RSC. Reviews of specific procedures may be conducted on a more frequent basis.

b. The RSO will review, at least quarterly, the radiation exposures of licensed investigators and workers to determine if their exposures are ALARA in

accordance with the provisions of Section F and with appropriate regulatory and license conditions and provide a report to the RSC.

2. Education Responsibilities for an ALARA Program

   a. Educational training sessions to workers will include ALARA program concepts.

3. Cooperative Efforts for Development of ALARA Procedures

   Licensed Investigators and workers will be encouraged to participate in the formulation of procedures that they will be required to follow. The RSO will be receptive to receiving and evaluating the suggestions of individual investigators and workers for improving health physics practices and will consider the use of those practices.

4. Reviewing Instances of Deviation from Good ALARA Practices

   The RSO will investigate all known instances of deviation from good ALARA practices and, if possible, determine the causes. When the cause is known, the RSO will require reasonable changes in the program to maintain exposures ALARA.

D. Licensed Investigators (LIs)

1. Previously Unauthorized Procedures Involving Potential Radiation Exposures or Radioactive Gaseous or Liquid Effluents or both

   a. The LI will consult with and receive the approval of the RSO and the RSC during the planning stage before using byproduct material for previously unauthorized uses.

   b. The LI will ensure that exposures and effluent releases will be kept ALARA. This may be accomplished through the application of trial runs.

2. Responsibility of the LI to Those Supervised

   a. The LI (or the RSO or both) will ensure that workers under their supervision have been trained and educated in good health physics practices and maintaining exposures and effluent releases ALARA.

E. Workers

1. Training will include instructions in the ALARA concept.

2. Workers will know what recourses are available if they believe that ALARA is not being promoted on the job.

F. Investigational Levels

The establishment of investigational levels is to monitor individual occupational radiation exposures (as per NRC 10 CFR 20.1201 and State of CT DEEP Section 19-24-5 regulations) and concentrations of byproduct material in gaseous and liquid effluents (as per 10 CFR 20.1302, 10 CFR 20.2003, and State of CT DEEP regulations Section 19-24-14).

To facilitate the ALARA goal, dose thresholds have been established by the RSO that, when exceeded, initiate a review of radiation safety practices. The thresholds are based on a percentage of the NRC and State of CT DEEP dose limits. The ALARA review thresholds are provided in Table A-1 and A-2.

At the discretion of the RSO, an ALARA Level I or II review may be performed on any individual or group trend identified to be unusual or undesirable.

1. Individual Occupational Radiation Exposure Investigation Levels

   The University of Connecticut hereby establishes Investigational Levels for occupational radiation exposure that, when exceeded, will initiate review or investigation by the RSC, the RSO, or both. The Investigational Levels apply to the exposure of all individuals.

Table A-1
Investigational Levels: Individual Occupational Radiation Exposure

Dose Type		Level I (10% NRC) (mrem) (per year)	Level II (30% NRC) (mrem) (per year)	Level I (10% CT DEEP) (mrem) (per calendar quarter)	Level II (30% CT DEEP) (mrem) (per calendar quarter)
Whole body, head and trunk, active blood-forming organs, or gonads.	Total effective dose equivalent (TEDE)	500	1500	125*	375*
Lens of eyes	Lens dose equivalent (LDE)	1500	4500	125*	375*
Any organ or tissue (excluding eyes)	Total organ dose equivalent (TODE)	5000	15000	125*	375*
Hands and forearms, feet and ankles	Shallow dose equivalent (SDE)	5000	15000	1875	5625
Skin of whole body	Shallow dose Equivalent (SDE)	5000	15000	750	2250
Embryo or Fetus of declared pregnant woman (DPW)	Deep dose equivalent or Fetal (TODE)	50 (per month of declared pregnancy)	Not Applicable	Not Applicable	Not Applicable

*CT DEEP regulations Sec. 19-24-5 Maximum doses: "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk or lens of eye. An employee can be permitted to receive an occupational dose to the whole body greater than that permitted, provided:

a. During any calendar quarter the dose to the whole body from radioactive material and other sources of radiation shall not exceed three rem; and

b. The dose to the whole body when added to the accumulated occupational dose to the whole body shall not exceed five (N-18) rem where "N" equals the individual's age in years at their last birthday; and

c. The individual's accumulated occupational dose to the whole body has been determined on a clear and legible record.

2. Concentration of Byproduct Material in Gaseous and Liquid Effluents

The University of Connecticut hereby establishes Investigational Levels for byproduct material releases of gaseous and liquid effluents that, when exceeded, will initiate review or investigation by the RSC, the RSO or both. The University of Connecticut encourages radioactive decay and filtration of gaseous and particulate effluents prior to release to the environment. The Investigational Levels for gaseous and liquid effluents are:

Table A-2
Investigational Levels: Concentration of Byproduct Material in Effluents

	Level I (20%)	Level II (50%)
Yearly gaseous or particulate releases to air at each release point	≥ 20% of summed annual radionuclide fractions permitted, 10 CFR 20, APP.B, Table 2, Col. 1	≥ 50% of summed annual radionuclide fractions permitted, 10 CFR 20, APP.B, Table 2, Col. 1
Monthly releases to sewer	> 20% of summed monthly radionuclide fractions permitted, 10 CFR 20, APP.B, Table 3	> 50% of summed monthly radionuclide fractions permitted, 10 CFR 20, APP.B, Table 3
Accumulated total activity of radioactive material released into the sanitary sewer in a year	3H > 1000 mCi 14C > 200 mCi Total all others > 200 mCi	3H > 2500 mCi 14C > 500mCi Total all others > 500 mCi

3. Investigational Level Actions

The RSO will review and record on Form NRC-5, "Current Occupational External Radiation Exposures," or an equivalent form (e.g., dosimeter processor's report) the results of personnel monitoring at least once in each calendar quarter. The RSO will review the results of radioactive aqueous and liquid effluents at least quarterly. The exposures and radioactive effluent releases will be compared with the Investigational Levels in Tables A-1 and A-2 respectively, and the following actions will be taken:

a. Personnel exposures or effluent concentrations and releases less than Investigational Level I.

Except when deemed appropriate by the RSO, no further action will be taken in those cases in which an individual's exposure or an effluent concentration and release is less than values for Investigational Level I.

b. Personnel exposures or effluent concentrations and releases equal to or greater than Investigational Level I, but less than Investigational Level II.

The RSO will review the exposure of each individual whose accumulated exposure equals or exceeds Investigational Levels I. Individuals exceeding the ALARA Level I threshold in Table A-1 will be notified in writing of the event and will be asked to submit to the RSO a written explanation of the exposure or the RSO may have a conversation with the individual and document the specifics of the conversation pertaining to the exposure. The RSO will report the results of such reviews at the first RSC meeting following the quarter when the exposure was recorded and received by the RSO.

The RSO will review the radioactive materials released in gaseous and liquid effluents quarterly and will report any results which exceed Investigational Level I at the next scheduled RSC meeting.

If the exposure or effluent release does not equal or exceed Investigational Level II, no further action related specifically to the exposure or release is required unless deemed appropriate by the RSC. The RSC will, however, consider each such exposure and effluent release in comparison with those of others performing similar tasks as an indication of ALARA program quality and will record the review in the minutes of the RSC meeting.

c. Personnel exposures or effluent concentrations and releases equal to or greater than Investigational Level II.

The RSO will investigate in a timely manner the causes of all personnel exposures or effluent releases equaling or exceeding Investigational Level II and, if warranted, take action.

For personal exposures, individuals with exposures exceeding the ALARA Level II threshold in Table A-1 initiates the following:

i. Written notification to the individual and responsible supervisor (LI and Department Head).

ii. Written individual-specific recommended measures to reduce radiation exposure levels.

iii. Review of occurrence during the next quarterly RSC meeting. Provide a report of the investigation, actions taken, if any, and a copy of the individual's Form NRC-5 or its equivalent will be presented to the RSC at the first RSC meeting following completion of the investigation.

For gaseous or liquid effluents, a summary will be provided with details concerning the release. The details of these reports will be recorded in the minutes of the RSC meeting.

d. Establishment of an individual worker exposure or radioactive material gaseous or liquid effluent release above Investigational Level II listed in Tables A-1 or A-2.

If a worker or a group of workers' occupational exposures or effluent releases needs to exceed Investigational Level II, a new, higher Investigational Level II may be established on the basis that it is consistent with good ALARA practices for that individual, group, or situation in relation to the intended task. Justification for a new Investigational Level II will be documented in RSC minutes.

The RSC will review the justification for and will approve all revisions of Investigational Level II. In such cases, when the exposure or effluent concentration and release equals or exceeds the newly established Investigational Level II, those actions listed in Section c above will be followed.

APPENDIX C: Responsibilities of EHS Radiation Safety

1. Providing continual surveillance of all radiation safety activities related to accelerators, radionuclide laboratories, analytical x-ray machines and other equipment capable of producing ionizing or non-ionizing radiation.

2. Establishing procedures for purchasing, receiving, and shipping of all radioactive materials coming to or leaving UConn.

3. Managing the University's radiation dosimetry and instrument calibration programs.

4. Providing training to Users and Non-Users in proper radiation safety practices.

5. Managing a radioactive material waste disposal program, including the processing, storage, disposal, and shipping of radioactive waste.

6. Managing the free release of equipment and facilities formerly used for radioactive material procedures.

7. Managing the decommissioning of buildings where radioactive material is no longer used.

8. Responding to laboratory emergencies involving radiation exposure or contamination.

9. Providing consultative services regarding radiation safety to radiation source Users and others.

The EHS Radiation Safety Manager serves as the University's Radiation Safety Officer (RSO) for activities conducted under the University's license(s) with the Nuclear Regulatory Commission. The RSO is empowered by the Radiation Safety Committee to immediately terminate practices found to be a threat to health, safety, or property; and to stop the purchase of materials for any laboratory violation until the violation is corrected.

APPENDIX D: Responsibilities of the Licensed Investigator

1. Planning experiments to minimize radiation hazards. Radiation doses to workers and the public and releases to the environment should be kept as low as is reasonably achievable (ALARA). See Appendix E for list of radiation protection guides. Experimental procedures must be well outlined to allow adequate review of safety precautions.

2. Consulting with Radiation Safety prior to any new experiment using radioactive material.

3. Instructing all Users and Non-Users for whom they are responsible on safe techniques and approved radiation safety practices prior to allowing such persons to commence work within designated radioactive materials or radiation-producing equipment use areas.

4. Carrying out the radiation safety program in their laboratory including planning for possible radiation emergencies.

5. Notifying the RSO of any changes in personnel.

6. Requesting amendments of their protocols in a timely manner with Radiation Safety whenever there are significant changes in operational procedures, new techniques, space, or equipment.

7. Complying with University regulations governing the use of radioactive materials such as:

    a. Using proper procurement and transfer procedures as outlined in Sections VI.

    b. Posting areas where radionuclides are kept or used, or where radiation fields may exist.

    c. Securing radioactive materials in their possession to prevent unauthorized use.

    d. Recording the receipt, transfer, and disposal of radioactive materials in their area. Inventory data shall be submitted to Radiation Safety when requested.

    e. Ensuring that all radioactive waste materials are disposed of in accordance with University procedures, including preparation of radioactive waste for transfer to Radiation Safety for disposal.

f. Ensuring that appropriate records of radionuclide usage are maintained and reported to Radiation Safety when requested.

g. Providing adequate and appropriate instrumentation for assessing potential radiation hazards in their area and performing surveys of the work area, as necessary.

h. Taking steps to prevent the transfer of radioactive materials to unauthorized individuals. This includes the proper disposition of radioactive materials possessed by terminating employees or students.

8. Ensuring that the radiation exposures to service personnel are minimized while working on equipment, hoods, or sinks in radioactive material areas. Radiation Safety shall be notified before the work is carried out.

9. Complying with proper procedures for terminating employment or terminating an experiment using radioactive materials. The LI must make appropriate arrangements for the return of all radioactive materials to Radiation Safety, including waste, possessed by them under the license. Particular care should be exercised to see that specialized equipment such as personnel monitoring devices are returned to Radiation Safety.

10. Notifying the RSO if they are to be absent from the University for more than one month. Arrangements shall be made for another LI to take responsibility for the licensed materials and subordinate research staff of the absent LI.

APPENDIX E: Responsibilities of Radioactive Material Users

1. Being familiar and compliant with the University's Radiation Safety Program.

2. Wearing assigned personnel monitoring equipment while working with radioactive material or radiation producing equipment.

3. Surveying self, equipment, and work areas for radioactive contamination before, during and after radioactive materials experiments. Taking appropriate steps to remove and report any detected radioactive contamination as required before leaving the laboratory.

4. Utilizing all appropriate protective measures whenever working with unsealed forms of radioactive material (i.e., liquid or powder form) such as:

    a. Wearing the required personal clothing with no exposed skin including long pants or long skirt and fully enclosed footwear and wearing the proper personal protective equipment (PPE) including nitrile gloves, lab coat, and safety glasses or goggles. Additional PPE, such as a face shield worn over glasses or goggles, may be required as determined through the Workplace Hazard Assessment.
    b. Wearing respiratory protection when specified by the RSO.
    c. Using protective barriers and other shields whenever appropriate to minimize personnel doses.
    d. Using remote handling equipment when appropriate to reduce exposure.
    e. Using pipette-filling devices. Never pipette by mouth.
    f. Performing radioactive work within the confines of an approved hood or glove box when appropriate or required.

5. No eating, drinking, smoking, applying cosmetics or evidence thereof, in areas where radioactive materials are present. Refrigerators or freezers used for the storage of radioactive materials shall not be used jointly for food or beverages for human consumption.

6. Maintaining good personal hygiene. Not working with radioactive materials if there is an open or an unprotected break in the skin below the elbow. Wash hands and arms thoroughly after working with radioactive materials.

7. Checking periodically for contamination in all work areas in which radioactive materials are being used (including work surfaces and floors), as well as equipment and instrumentation designated for use with radioactive materials.

    a. If an area exceeds the limit for contamination (100dpm per 100cm^2), the User shall: (i) notify the Licensed Investigator (LI) of the contamination, (ii) decontaminate the area using the spill kit provided by Radiation Safety, (iii) document the contamination and decontamination process appropriately.

    b. If an area meets the criteria for extensive contamination (>10,000dpm per 100cm^2), or if contamination, regardless of amount, is detected on the floor, outside the controlled area, or on personnel, it shall be reported to the LI and Radiation Safety immediately. See Radiation Emergency Procedures, Appendix I for further information.

8. Keeping the laboratory neat and clean. The work area should be free from equipment and materials not required for the immediate procedure. Taking care to transport materials in such a manner as to prevent breakage or spillage (e.g., double container, plastic containers) and to ensure adequate shielding. Keep work surfaces covered with protective material, preferably in a “Safe-tray” or pan, to limit and collect spillage in case of accident.

9. Appropriately labeling and isolating radioactive waste and equipment, such as glassware used in laboratories for radioactive materials. Once used for radioactive substances, equipment shall not be used for other work and should not be permitted to leave the area until demonstrated to be free of contamination.

10. Requesting the assistance of Radiation Safety for any emergency repair of contaminated equipment in the laboratory.

11. Reporting accidental inhalation, ingestion or injury involving radioactive materials to the LI and Radiation Safety and carrying out their recommended corrective measures. The individual shall cooperate in any and all attempts to evaluate their exposure. (See Radiation Emergency Procedures, Appendix I for further information.)

12. Carrying out decontamination procedures when necessary and taking the necessary steps to prevent the spread of contamination to other areas.

13. Complying with regulations concerning bioassay samples and tests.

14. Reporting safety concerns involving radioactive material use or exposure immediately to Radiation Safety.

APPENDIX F: Procedures for Receiving and Opening Radioactive Material Packages

A. Radiation Safety

Radiation Safety shall perform the following procedure when receiving packages containing radioactive material:

1. Put on gloves to prevent hand contamination.
2. Visually inspect package for any sign of damage (e.g., wetness, crushed). If damage is noted, stop the procedure, and notify the Radiation Safety Officer.
3. For a package that has a radioactive transportation label (e.g., Yellow II), then the following steps apply:

a. Measure exposure rate on contact and at one meter from package surface and record within three hours of receipt.
b. If the meter survey results are greater than the package Transport Index (TI) on the label, stop the procedure and notify the Radiation Safety Officer.

4. For all packages, obtain a wipe test survey on the outside of the package. If the wipe test survey result is >100dpm per 100cm^2 notify the Radiation Safety Officer.
5. Record results on "Radioactive Shipment Receipt Record".
6. Verify the amount on the packing slip with the requisition amount entered in the radioactive material order log and the Radiation Safety copy of the LI's current inventory spreadsheet.
7. Deliver radioisotope package to appropriate radioisotope laboratory.
8. Obtain a signature from individual receiving the package on the original "Radioactive Shipment Receipt Record" and on a copy of the form. Leave the LI laboratory the copy to complete and to keep with their package opening wipe test results. The original will be kept on file with Radiation Safety.

B. Authorized Radioactive Material User

Upon receipt of the package, trained laboratory personnel shall perform the following:

1. Store package in a secure location.
2. Add the amount of radioactivity received to the current radioisotope inventory.
3. Use the Radiation Safety provided "Radioactive Shipment Receipt Record" to document the opening of the received package. Complete and sign the form.
4. Upon opening of the package take the following precautionary steps:
    a. Wear protective clothing and other required PPE.
    b. Open the outer package and remove the packing slip.

c. Open the inner package and verify the contents agree with that on the packing slip. Compare requisition, packing slip and label on the stock vial or final source container label.
d. Check the integrity of the final source container (i.e., inspect for breakage of seals or vials, loss of liquid and discoloration of packaging material.
e. Wipe the internal surfaces of the shipping box and shipment tray or packaging, the external surface of the shipping capsule (i.e., pig), and the external surface of the final source container (i.e., stock vial). Assay the wipes and record amount of removable radioactivity. Notify Radiation Safety of contamination results >100 dpm. If items are not contaminated, obliterate (completely destroy) outer package radioactive labels, the word "radioactive" from anywhere it appears and radiation symbols before discarding outer package and packing materials in regular trash.
f. Attach the wipe test survey documentation to the completed "Radioactive Shipment Receipt Record" and retain in records.

APPENDIX G: Radioactive Waste Procedures for Laboratories

A. Waste Security

Each Licensed Investigator (LI) is responsible for the safe and secure storage of their radioactive waste until Radiation Safety picks it up. This means that the waste should be properly secured from unauthorized removal. All radioactive waste containers shall be kept in the controlled areas of the laboratory, not in the hall or other unsecured area, as this represents a violation of NRC regulations and subjects an LI to revocation of their license. Waste should also be stored with sufficient shielding to minimize the radiation exposure levels to ALARA to any individual in the laboratory.

Contact Radiation Safety immediately if unauthorized individuals remove or attempt to remove radioactive materials or radioactive waste from a laboratory.

B. Waste Categories

Each laboratory shall segregate their radioactive waste into a number of different categories. Short half-life (half-life ≤120 days) waste must be separated from the long half-life (half-life >120 days) waste. Short half-life waste must be further segregated by radionuclide. Biological waste, hazardous waste, and animal waste that are contaminated with radioactivity must all be inventoried, labeled appropriately, and stored separately. There shall also be separate radioactive waste containers for liquid, liquid scintillation vials (LSVs), dry waste, and sharps.

No mixed waste (regulated hazardous waste contaminated with radioactive material), shall be generated unless it is authorized and prior approval is obtained in the LI's protocol. Fees associated with the proper disposal of mixed waste may be charged to the PI or department of the laboratory that generated the mixed waste. Material must not be put into radioactive waste collection containers if there is any possibility of a chemical reaction during storage or shipment that might cause the release of radioactive gases, fire, or explosion. Radioactive waste containing a volatile iodine radionuclide should be sealed in plastic bags prior to pick up due to the volatile nature of iodine. Lead being disposed of is considered a hazardous waste. Therefore, empty lead stock vial containers (i.e., lead pigs) are required to be segregated for pick-up by Radiation Safety.

Laboratory personnel are required to use radioactive waste containers provided by Radiation Safety for radioactive waste collection. The containers provided are properly labeled and have a waste log sheet attached to the lid. Arrangements can be made for delivery of these waste containers via the EHS website. Each waste category shall be disposed of in a separate radioactive waste container. The dry waste containers shall not

include liquid, animal tissue of any kind, hazardous material such as chemicals, lead, sharps, or items that require refrigeration. Care should be taken to keep containers dry and not filled to a volume more than approximately three-fourths full.

Liquid scintillation cocktails must be non-hazardous and listed on the University's *List of Approved Liquid Scintillation Cocktails* which can be found on the EHS website or may be obtained by requesting it from Radiation Safety staff. Radiation Safety must be contacted with questions about any cocktails not on the list prior to utilization. Do not pour the contents of the liquid scintillation vials down the drain. Radiation Safety will collect the intact vials for proper disposal.

In any given laboratory there can be many radioactive waste categories. For example: A laboratory has the following two protocols: 1. Using C-14 in cell cultures and 2. Using I-125 in mice. The following separate long and short half-life waste categories could result for each isotope:

Long half-life waste associated with the C-14:

1. Dry waste (gloves, plastic, and paper)
2. Aqueous waste
3. Animal waste
4. Sharps
5. Liquid scintillation vials
6. Empty lead stock vial containers (i.e., pigs) or other hazardous waste approved to be generated in a research protocol

A similar list of short half-life categories would apply to the I-125. The LI should consult with Radiation Safety if there are questions regarding which waste categories are appropriate.

Uranium and thorium compound waste must also be segregated and managed as radioactive waste. Barcodes on empty chemical bottles previously containing thorium and uranium compounds must be sent to EHS prior to disposal for compliance with the *Laboratory Chemical Inventory Program*. Unwanted thorium and uranium compounds or waste containing thorium and uranium must be disposed of through Radiation Safety.

C. Waste Collection and Pick-Up Procedures

Waste Logs

As the waste container is being filled, remove the empty tag from the lid and keep accurate records of the specific radionuclides, quantities, and dates that the waste is being placed in the container. These records shall be kept on the waste disposal log provided with each

receptacle. There must be a waste log entry for any waste put into the container, including items such as gloves with trace radioactivity.

Radioactive Material Label Removal

Remove and obliterate radioactive material labels from all short half-life waste prior to disposal in a designated waste container. Labels may be obliterated prior to disposal by tearing them up or completely covering the words “radioactive material” and all radiation symbols by: 1) covering with a thick, permanent marker; 2) completely covering with duct tape; or 3) other means that permanently removes the radioactive materials warnings.

Waste Storage

The presence of the receptacle within the laboratory should not constitute a health hazard. If significant dose rates are associated with the container, special arrangements should be made through Radiation Safety for recommendations concerning proper shielding or different methods for handling waste should be arranged. Acrylic (e.g., Lucite or Plexiglass) rather than lead should be used as the shielding for P-32 waste and lead shielding for gamma emitters. If additional shielding is needed for high energy beta emitters, use Lucite on the inside of the shield and lead on the outside.

Waste Removal

Waste container removal can be requested by going to the EHS website and filling out the on-line radioactive waste pick-up request form. Scheduling a waste pick-up necessitates advance notice; allowance must be made to anticipate full containers (not over-flowing) at the time of pick up. LIs are reminded of their responsibility for safe and secure storage of the waste until removed by Radiation Safety. Prior to pick-up, laboratory personnel must perform the following:

1. The exterior of each container shall be wipe-tested to assure that any removable contamination is less than 100dpm per 100cm^2. The wipe tests shall include the handle, top, sides, and the bottom of each container being picked up and documented appropriately.

2. Each container shall have a completed waste log sheet indicating the specific radionuclide(s), total amount of activity disposed, associated dates of disposals, LI name, waste class, and the name of the liquid scintillation cocktail, if applicable.

3. Enter the waste pick-up date and activity amount on the current quarter inventory spreadsheet when Radiation Safety removes from lab.

D. Waste Processing

Radiation Safety is responsible for the processing of most of the radioactive waste. The short half-life waste is allowed to be decayed on-site for at least ten half-lives at which time it is no longer considered radioactive if the radiation levels cannot be distinguished from natural background. Long half-life wastes are accumulated and sent through a licensed broker to disposal sites that have been duly licensed by the NRC or State agency or both.

Aqueous waste can be disposed of into the sanitary sewer and must be readily soluble in water, biological material readily dispersible in water, or otherwise suitable for disposal into a sanitary sewer and within the limits of concentration and activity. Each LI is allowed to release up to one millicurie per week total of all isotopes combined into a designated sink within the laboratory. The weekly limit applies to the combined total disposals for all designated sinks in the LI laboratory, not per sink. There must be a thorough flushing with several gallons of water each time radioactivity is released to the sanitary sewer. A record of the isotope, volume, activity, and date of each disposal released must be kept. The sink must be surveyed after each disposal and decontaminated if radioactive contamination is present.

E. Deregulation of C-14 and H-3 Waste

NRC and UConn regulations allow for the deregulation from radiation control of small concentrations (< 0.05 µCi per g) of C-14 and H-3 in scintillation cocktails or animal carcasses. Radiation Safety will pick up the deregulated liquid scintillation vials for proper disposal in accordance with waste collection procedures specified in this section. Do not pour the contents of the liquid scintillation down the drain. Radiation Safety will collect the intact vials for disposal. Deregulated animal carcasses must be disposed of in accordance with appropriate Biological Safety procedures.

F. Animal Carcasses and Associated Waste

1. LIs authorized to use animals by the IACUC and the RSC in their radionuclide research shall make provisions for packaging and freezing the carcasses in a secure location until picked up by Radiation Safety.

2. Bags containing animal carcasses and associated waste shall be labeled with the specific radionuclide, date, activity, and weight of the containerized carcasses or tissue.

G. Radioactive Viruses

1. All liquid preparations containing infectious viruses and radioactive compounds shall be mixed with an appropriate agent such as bleach to destroy the virus, then neutralize before disposal.

2. All solid waste contaminated with infectious viruses and radioactive compounds should be autoclaved before being placed in the radioactive waste receptacles. Care should be taken so that disposable glassware, etc., which might have radioactive contamination on the outside does not touch the walls of the autoclave. Additionally, radionuclides attached to highly volatile compounds should not be used in procedures that require autoclaving.

H. Excess and Unwanted Radioactive Material

Contact Radiation Safety for removal of excess or unwanted radioactive material.

APPENDIX H: Policy for Visitors in Radioactive Material Laboratories

If a visitor is a short term, Non-User, the Licensed Investigators (LIs) are responsible for providing lab specific training in their lab(s). Radiation Safety must train a visitor using a radioisotope(s), regardless of time spent in the laboratory, prior to using radioactive materials at UConn. If a Non-User visitor is still in the lab after 1 month, they must attend the official UConn Non-User Radiation Safety training. Ancillary personnel (e.g., repair or service personnel) who have not completed the appropriate UConn Radiation Safety training, as determined by the RSO, must be escorted at all times by trained lab personnel or be provided lab specific training or instruction by the LI or appropriate designee. For the Research Vessel (RV) Connecticut: At any time when isotopes are on board the ship, visitors to the RV Connecticut will be required to attend Radiation Safety Training specific to the ship.

A visitor is anyone entering a laboratory or area posted with “Caution Radioactive Materials or Area” signage that is not listed on the Protocol as a User or Non-User of that lab. This applies to all UConn and non-UConn employees or affiliated individuals. If a Non-User from another lab stores or uses items on a regular basis in an LI’s radioactive materials lab, then that individual must be listed as a Non-User on that LI’s Protocol and must attend the appropriate Non-User training. An LI who is responsible for a multi-use or shared equipment laboratory, (e.g., liquid scintillation counter (LSC) room) is not responsible for ensuring that the training requirements have been fulfilled for those individuals from another LI laboratory using the equipment and is not required to list those individuals as Non-Users on their Protocol. However, if the individuals are from a non-radioactive materials laboratory, the LI is responsible for ensuring the individuals complete the required Non-User training requirements and adds them to their protocol.

APPENDIX I: Emergency Procedures

I. EMERGENCY PHONE NUMBERS

University Safety Emergency Communications:	860-486-4800 (Non-Emergency Incidents) 911 (Emergency)
EHS Radiation Safety:	860-486-3613 (Regular Business Hours M-F)

II. EMERGENCY PROCEDURES

This section applies to emergencies involving radiation exposure and radioactive contamination. Emergencies are those situations in which an individual's health and safety and or property are at risk or are not under control and immediate help is needed. Emergency procedures and contacts are contingent upon the timing and extent of the contamination incident.

For all emergencies keep calm, use common sense, protect people, do not spread contamination, and always assume you are contaminated until a survey shows otherwise.

A. Incidents Involving Radioactive Contamination

1. Emergency procedures and contacts

a. If the incident occurs **during regular business hours**:
Call Radiation Safety 860-486-3613 when the incident occurs.

b. If the incident occurs **after regular business hours** and involves contamination that is **well-contained in a controlled area**:
Follow the procedures described in and in your laboratory Protocol (Section IV.E) and Appendix J: After-Hours Emergency Response Policy. This includes notifying your Licensed Investigator (LI) and addressing the contamination as specified in your Protocol.

c. If the incident occurs **after regular business hours** and involves **the floor, personal contamination, or is outside of the controlled area**, or presents a situation in which **assistance is needed**:

Call University Safety Emergency Communications (860-486-4800) to get outside help by requesting to speak to a member of EHS Radiation Safety. You will supply the following information:

a. Location of accident.
b. Number of people involved or injured.
c. Radionuclide and amount of radioactivity involved.
d. Type of radiation exposure if applicable (i.e., surface exposure, ingestion, injection, inhalation).
e. Your name and telephone number.

2. Confine any Contamination

a. Use the spill kit provided by Radiation Safety. Localize the spill. Pick up any tipped containers, drop absorbent material on a liquid spill, and dampen down a dry spill to prevent airborne contamination. Always wear gloves when working with a spill.
b. Do not track contamination throughout the laboratory. If possible, call for help without leaving the area. Prevent others from entering the immediate contamination area.
c. Keep all personnel involved together close to the incident area.
d. Close doors and where possible adjust ventilation to prevent the spread of airborne contamination.
e. Place a sign at the entrances and exits warning about the contamination.
f. Check your shoes before leaving the area of a cleaned up spill.
g. If you must remove yourself from the scene or building remain in the general vicinity until emergency personnel arrive and authorize you to leave.

3. Protect Personnel

a. Warn other workers of the accident.
b. Use mechanical means (not hands) to pick up or remove broken glass or other sharp objects.

4. Decontamination of Personnel Contaminated with Radioactivity

a. Remove contaminated clothing.
b. For skin contamination, obtain a direct meter survey reading on the area of contamination and note the scale setting of the meter.

c. Begin gently washing contaminated parts of the body with mild detergent (neutral pH) and lukewarm water. The decontamination should be done over the designated radioactive material disposal sink.
d. Do not abrade the skin. Stop decontamination of the skin if attempts to decontaminate are not significantly reducing contamination levels.
e. Notify Radiation Safety and the LI immediately following decontamination attempts. After hours contact UConn University Safety at the appropriate telephone number listed in Section I and advise to them contact Radiation Safety personnel. Remain in the laboratory until Radiation Safety is consulted.

B. Incidents Involving Both Personnel Injury and Radioactive Contamination

1. Call 911 for medical help if needed.

2. First Aid

a. Remove contaminated clothing and gently wash contaminated parts of the body with mild detergent (neutral pH) and lukewarm water. Fire blankets may be used as emergency clothing if necessary.
b. If a minor injury results, the injured person should flush the contaminated wound thoroughly with room temperature sterile saline or water and gently wash with a surgical sponge before bandaging. The decontamination should be done over the designated radioactive material disposal sink.
c. An emergency responder or individual voluntarily administering first aid must wear gloves and other personal protective equipment as necessary to protect themself from contamination and from contact with the blood of the victim. Always wash hands thoroughly after removing gloves.
d. Use mechanical means (not hands) to pick up or remove broken glass or other sharp objects.

3. Emergency Procedures and Contacts

a. Notify the Licensed Investigator
b. Notify EHS Radiation Safety at 860-486-3613 as soon as possible (if after work hours, Radiation Safety personnel can be reached through UConn University Safety at the appropriate telephone number listed in Section I and advise to them contact Radiation Safety personnel).
c. Follow all additional procedures in Section II, Part A.

C. University Safety Emergency Communications and Emergency Responders Procedures

1. University Safety Emergency Communications procedures

a. Upon receiving a call about an incident involving radioactive materials or radiation exposure, the dispatcher should collect the following information:

   i. Location of incident.
   ii. Number of people involved or injured.
   iii. Radionuclide and amount of radioactivity involved.
   iv. Type of radiation exposure if applicable.

b. Name and telephone number of the individual giving the information. University Safety Emergency Communications personnel should notify the Radiation Safety Officer or Radiation Safety staff and relay the information.

2. UConn Emergency Responders procedures

a. Emergency responders dispatched to the scene, should do the following:

   i. If injuries are involved, apply first aid, and summon an ambulance if appropriate.
   ii. Work with laboratory personnel to determine the extent of radioactive contamination (the UCFD survey meters or the survey instruments in the laboratory are best suited for measuring contamination).
   iii. Remove any contaminated clothing (e.g., gloves, lab coats) if it can be done without aggravating injury.

b. Keep Radiation Safety informed if they are not already present at the scene.
c. Obtain the names and addresses of any person who is, or may have been, affected in the immediate area.
d. When ambulance or rescue squad personnel arrive, they should be informed if there is a known or suspected presence of radioactive material.
e. Keep the public away from the incident area. Detour vehicular and pedestrian traffic as for a fire.
f. Any contaminated individuals should be wrapped in a blanket or other means used to contain the contamination if present. Call the hospital Emergency Room, if necessary, and indicate the number of patients that will be coming.
g. After UConn emergency responders have taken an injured person to a doctor, hospital or other medical facility, they should not leave this location until they and their vehicle have been checked for contamination either by UConn

Radiation Safety personnel or other qualified radiation monitors (e.g., CT DEEP, NRC).

III. INCIDENT REPORTING

All information released to the public concerning incidents involving radiation shall be released through University Communications after consultation with UConn's Environmental Health and Safety Director and the RSO.

APPENDIX J: After-Hours Emergency Response Policy

Radiation Safety personnel are available to respond to emergencies involving radioactive contamination on campus during regular business hours. If the emergency occurs outside of the regular business hours, the initial response must be provided by laboratory personnel, the Licensed Investigator (LI), and if necessary, the University's first responders, (fire and police), who have been trained by the RSO may assist in controlling access to the affected area. The LI is primarily responsible for contamination monitoring and decontamination during after hour emergencies. While Radiation Safety personnel are not technically "on call" after-hours, they can be called for guidance (a list of Radiation Safety personnel home numbers is maintained by the University Fire and Police Departments.) If the situation merits, and they are available, Radiation Safety personnel may respond to the emergency scene outside of normal working hours.

All authorized Users shall make provisions for adequately responding to laboratory emergencies involving radioactive materials after-hours. These provisions should be outlined in their protocols. The potential for having a contamination emergency is dependent on the amount and type of radioisotope that is being handled. A good index for measuring this potential is the Annual Limit of Intake (ALI)* of the radioisotope (an intake of one ALI is equivalent to a whole-body dose of 5 rem). The potential for a contamination emergency is also dependent on the physical and chemical form of the isotope. Radioisotopes that are in a bound form such as a gel are more stable and less likely to spread during an accident. Work with stock solutions should be limited to during regular business hours. After-hours work with radioactive material should be limited to more dilute solutions. Table I lists some possible approaches that LIs can take based on the type and quantity of the radioisotope being used.

Table I
Planning Strategies for After-Hour Radioisotope Emergencies

Amount of Radioisotope Fraction of ALI	Strategy
<0.01	No special planning necessary
0.01-0.10	Licensed Investigator (LI) or experienced worker is readily available or on call **or**, Limit after hour use to stable isotope forms which have low probability of contamination spread or, Require that work be done in glove box or hood.
>0.1	LI or experienced worker is readily available or on call **and**, Limit after hour use to stable isotope forms which have low probability of contamination spread or, Require that work be done in glove box or hood.

*ALI = Annual Limit of Intake is equivalent to an annual whole body dose of 5,000 mrem. The following are ALI values for commonly used radionuclides:

Isotope	0.01ALI (µCi)	0.1 ALI (µCi)
H-3	800	8000
C-14	20	200
P-32	6	60
P-33	60	600
S-35	14	140
I-125	0.4	4
Ho-166	9	90

The RSO should be contacted to provide the ALI information for authorized radionuclides not listed above.

APPENDIX K: Action Levels for Violations

Severity Level I
A major violation in which someone is intentionally or through willful neglect is allowed to receive radiation doses in excess of the currently established radiation protection guides or shows willful negligence in the management of personnel and laboratories under their supervision.

Action Level I
Requires immediate investigation by EHS Radiation Safety and the Licensed Investigator (LI). The LI shall file an incident report with Radiation Safety within 24 hours following the incident. The LI also shall show cause to the Radiation Safety Committee why the laboratory operations should not be suspended or terminated.

Severity Level II
Very significant violation in which someone is allowed to receive radiation doses in excess of the currently established radiation protection guides or shows continuing negligence in the management of personnel and laboratories under their supervision.

Action Level II
Investigation by Radiation Safety and the Licensed Investigator (LI) shall file an incident report with Radiation Safety within one week following the incident. The LI also shall show cause to Radiation Safety Committee that laboratory operations should not be temporarily suspended.

Severity Level III
A pattern of significant violations in which there is a potential for significant unnecessary radiation exposure or environmental releases or degradation of radiation source security.

Action Level III
Investigation of a possible violation pattern and an audit by Radiation Safety with a written report to the Radiation Safety Committee as part of the Radiation Safety Committee Minutes.

Severity Level IV
Violation of the requirements of the Radiation Safety Manual or safety standards set by the Radiation Safety Committee. This may include a violation in which there is a potential for an exposure or release above the allowable limits or diminution of source security.

Action Level IV
A letter of noncompliance is sent to the Licensed Investigator outlining specific actions to be taken. These may include, but are not limited to, a stepped-up frequency of laboratory surveys. Radiation Safety also may increase the frequency of audits.