

Radiation Safety Manual

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Applies To: Employees, Students, Others

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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 radiation exposure to University of Connecticut employees, laboratory workers, and the general public as well as to assure compliance with Federal and State regulations. This program is designed to maintain radiation exposure to radiation workers and the public as low as reasonably achievable (ALARA). Hereafter, radioactive material applies to licensed radioactive material.

B. RESPONSIBILITIES

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

1. Radiation Safety Committee: This is a group of scientists and administrators appointed by the University to establish policies and procedures governing the use of ionizing radiation at the University of Connecticut. The appointments are made using Nuclear Regulatory Commission (NRC) guidelines.
2. Radiation Safety Office: 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 office.
3. Licensed Investigators: University faculty or non-faculty members whose training and experience are such that they have been authorized by the Radiation Safety Committee to supervise the use of ionizing radiation in their research laboratories. **Licensed Investigators are responsible for all aspects of their laboratory's radiation safety program.**
4. 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 a Licensed Investigator.

B. SCOPE

The policies and procedures contained in this manual apply to all departments, laboratories, and persons using and possessing radioactive material and other

radiation sources on the University of Connecticut campuses located at Storrs, Mansfield Depot, Avery Point, Stamford, Waterbury and Torrington.

C. 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.

D. 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 University of Connecticut Student Conduct Code.

II. Program Elements

A. RADIATION SAFETY COMMITTEE

The Radiation Safety Committee (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 radiation research community, in addition to a representative of the University's Administration. The Radiation Safety Officer is a 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 campuses of the University of Connecticut with the exception of 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 Radiation Safety Officer 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 Radiation Safety Officer and the responsible individuals. The committee is the ultimate resolution body regarding issues of radiation safety. A detailed list of the Radiation Safety Committee members and their contact information can be found in Appendix A.

B. RADIATION SAFETY OFFICE

The Radiation Safety Office is part of the EHS Department and is the operational arm of the Radiation Safety Committee and manages the radiation safety program at the University. It is responsible for ensuring the University's compliance with Federal and State radiation safety regulations. A detailed list of Radiation Safety Office responsibilities can be found in Appendix B.

C. RADIATION SAFETY INSPECTIONS

The Radiation Safety Office will perform quarterly compliance inspections in all laboratories using radioactive sources with the exception of those with licenses declared to be inactive by the Radiation Safety Office.

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

D. LICENSED INVESTIGATOR

Licensed Investigators (LIs) are issued a radioactive materials usage license by the RSC and are responsible for insuring 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 C.

E. INDIVIDUAL USER

Each individual at the University of Connecticut who works directly with radioactive materials or radiation producing equipment is called a radiation user. Radiation users are responsible for following the protocol approved for his/her laboratory and following all pertinent University practices and procedures. A listing of radiation safety procedures for radioactive material users can be found in Appendix D.

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/or supervise the work. This individual is usually a faculty member, although non-faculty individuals may qualify depending on their experience and training. Application forms are available from Radiation Safety or from the Radiation Safety section of the Environmental Health & Safety (EHS) website.

B. PERMISSIBLE RADIONUCLIDES

The University of Connecticut's Type A broad scope license from the U.S. Nuclear Regulatory Commission (NRC) lists the isotopes that may be used at the University of Connecticut. Contact the RSO if you have a question regarding which isotopes are authorized. Radionuclides not listed cannot be used unless the University applies for and receives a license amendment from the NRC. Authorization must be obtained from the RSC prior to use or storage of licensed material.

C. REVIEW AND APPROVAL PROCEDURE

1. Licensed radioactive material shall not be used in or on human beings as stated in the University's NRC license conditions.
2. To become a Licensed Investigator of a radioactive material use laboratory, the following steps must be taken:
 - a. Secure both a Protocol Application form and a Statement of Training form from the Radiation Safety section of the EHS website or from the Radiation Safety Office. These forms must be completed in detail, and returned to the Radiation Safety Office. Consult with the RSO if you need assistance with the completion of these forms.
 - b. Contact the Radiation Safety Office and make arrangements to attend an appropriate radiation safety-training program.
3. New protocols are 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 the Radiation Safety Office, 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 the Radiation Safety Office 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 D.

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 should 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 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." 10 CFR 20 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 the Radiation Safety Office in limited quantities.)
 - iii. Laboratory containers such as beakers, flasks and test tubes used transiently in the laboratory procedures should 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

Preparations for decontamination of an area or equipment should begin as soon as the contamination is found. The first step is to determine the extent of the contamination. Contamination that is a result of a minor spill that occurs during the routine course of work and is readily contained on a work tray or absorbed by bench paper should be addressed by trained radioactive material users. The Radiation Safety Office will assist in the evaluation of the contamination incident if it involves contamination on the floor, outside the controlled area, or personal contamination. The individual responsible for the contamination will do the clean up under the supervision of the

Radiation Safety Office. The area or equipment is considered contaminated until proven otherwise.

2. Radioactive Spill

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 are detailed in Appendix I. The emergency policy applicable to weekends and after regular working hours is detailed in Appendix J.

3. Decontamination

Trained radiation workers should use the Radiation Safety provided spill kit 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", "Isoclean decontaminant", "Simple Green" or other appropriate cleanser.
- c. Work from the outside of the contaminated area toward the center being careful not to spread the contamination. Clean and re-survey until final wipe test contamination levels are below 100 dpm/100cm².
- 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 permissible 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 low 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 the Radiation Safety Office 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 the Radiation Safety Office before conducting experiments with radioiodine and the facilities must be evaluated for containment purposes.

D. STORAGE OF RADIOACTIVE MATERIAL

1. 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.
2. 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 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 (ECD's within Gas Chromatographs, Liquid Scintillation Counters, etc.) shall be registered with the Radiation Safety Office. This equipment shall be labeled with a "Caution Radioactive Material" sign or other label approved by the Radiation Safety Office. The sources shall be leak tested if required by the provisions of the general license. The Radiation Safety Office 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 exposures 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/year. Consult with the RSO during the planning stages of the demonstration.

G. VISITORS IN RADIONUCLIDE LABORATORIES

Licensed Investigators shall restrict casual traffic through laboratory areas where radioactive materials are used. Untrained visitors must be escorted at all times by an authorized radiation safety trained individual. Extra precautions should be taken by authorized users 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 techniques of radiation protection. The Radiation Safety Office 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 the Radiation Safety Office. **Both radioactive Materials Users and Non-Users in the laboratory shall complete the initial training prior to working in the laboratory.**

The Licensed Investigator must also provide new laboratory users and non-users with on-the-job, laboratory specific training related to radiation safety. The Licensed Investigator 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 bi-annually. Sessions are arranged in conjunction with the LI's Protocol renewal date and conducted at his/her laboratory.

V. Surveys and Monitoring**A. POST-OPERATIONAL SURVEYS**

Users shall conduct an appropriate survey after each use of unsealed radioactive material. All areas including the floor and equipment where the radioactive material was used shall be included in the post-operational survey. For all radionuclides with the exception of tritium (H-3), a post-operational meter survey shall be performed and documented on the appropriate survey form. If the meter survey shows radiation levels are detected above background, the affected area shall be decontaminated and a final wipe test shall be taken to determine if residual contamination is below 100 dpm/100 cm². For H-3 use, a post-operational wipe test survey shall be required. The post-operational wipe test shall be counted in the appropriate equipment, either a liquid scintillation counter (LSC) or gamma counter, and documented on the appropriate survey form with the wipe test locations and results attached.

For wipe test surveys for any radionuclide, results in excess of the University's removable contamination limit of 100 dpm/100 cm² shall be considered contaminated. Radiation Safety shall be notified of removable contamination levels for any radionuclide exceeding 10,000 dpm/100 cm² to ensure the contamination was adequately addressed.

Each laboratory using radioactive materials must provide the appropriate radiation detection instruments to enable personnel to conduct routine surveys for radiation exposure and/or surface contamination. The Radiation Safety Office 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. The Radiation Safety Office, 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 the Radiation Safety Office. 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. The Radiation Safety Office provides the laboratory with a replacement survey meter to use during calibrations or on a temporary basis if

needed. Spare replacement batteries should be kept in the LI laboratory. The Radiation Safety Office can provide batteries if needed.

B. PERSONNEL MONITORING

Except for individuals using soft beta emitters (max. energy <0.2 MeV) or pure alpha emitters, everyone 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 the Radiation Safety Office. Individuals leaving the University who no longer require the badge should complete and submit a monitoring 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 the Radiation Safety Office 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 his/her annual exposure report under the provisions of the Nuclear Regulatory Commission regulation 10 CFR 19. Exposure records are on permanent file at the Radiation Safety Office.

C. BIOASSAYS

Appropriate bioassays are required if there is a potential for an adult individual to receive an intake in excess of >10.0% of the applicable radiation exposure Annual Limit on Intake (ALI) values in 10 CFR Part 20 Appendix B (Table 1, Columns 1 and 2) either from an accident or normal operations. These tests should be arranged through the Radiation Safety Office.

1. Beta/Gamma Emitters

Individuals working with unsealed beta/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 the Radiation Safety Office. A baseline thyroid count will be performed by the RSO or Radiation Safety Office 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.

D. LEAK TESTING OF SEALED SOURCES

1. Sealed sources and detector cells containing greater than 100 micro curies (*beta/gamma*) shall be tested for leakage and/or contamination at intervals not to exceed 6 months.
2. Sealed sources designed to emit alpha particles and have activities exceeding 10 micro curies shall be tested for leakage and/or 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, or they contain only a gas, or 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. The Radiation Safety Office is responsible for conducting the leak tests.

E. RADIATION SAFETY INSPECTIONS

The Radiation Safety Office will perform quarterly compliance inspections in all authorized Licensed Investigator radioactive material laboratories with the exception of licenses declared to be inactive by the Radiation Safety Office. These inspections include a review of radiation surveys, records and procedures specified as conditions of Licensed Investigator's Protocols, as well as a meter survey and/or contamination survey of the laboratory. This does not preclude the Radiation Safety Office from increasing inspection frequencies as necessary to assure and document University compliance. The RSO will review all quarterly

inspections and notify the Licensed Investigator of any violation. A list of compliance actions is included in Appendix K.

VI. Procurement and Transfer of Radionuclides

A. PROCEDURES FOR PROCUREMENT

Only Licensed Investigators or other radioactive material users authorized by the RSO are permitted to order licensed radioactive material. Prior to placing an order for radioactive material in the University's Quali Financial System (KFS), an authorized individual must:

1. Receive pre-requisite training from the Radiation Safety Office on proper procedures for procurement of radioactive material in the Quali system.
2. Ensure other authorized users who will be allowed to place radioactive material orders receive the pre-requisite training from the Radiation Safety Office.

Once authorization and the required training are completed, orders may be initiated in Quali by submitting a Radioactive Material Requisition Form in the KFS system and utilizing the appropriate codes in accordance with the procedures specified in the pre-requisite training.

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. Approvals for radioactive materials are made through the Radiation Safety Office, NOT PURCHASING. The Radioactive Material Requisition form is available through Radiation Safety. Completed forms must be included with the Quali order. **Orders must be placed well in advance of expected delivery to allow sufficient time for approvals and processing by the Radiation Safety Office and other University departments.**
3. Orders may be delayed or disapproved if discrepancies or errors are identified by the Radiation Safety Office.
4. Radioactive orders must not be placed with the University ProCard or other credit card.

B. DELIVERY OF RADIONUCLIDES

1. Packages Received During Normal Working Hours

The package will be delivered to the Radiation Safety Office where it will be monitored in accordance with DOT/NRC regulations and added to the appropriate LI inventory. The Radiation Safety Office will deliver the package to the Licensed Investigator. 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.

C. TRANSFER OF RADIONUCLIDES

1. If a Licensed Investigator wishes to transfer radionuclides to another Licensed Investigator within the same campus, he/she 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. **No radioactive material may be transferred to or from the University of Connecticut or used on another campus or outside of the University of Connecticut except as provided in the University's NRC license. The RSO shall be contacted prior to such transfers and uses.** 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 the Radiation Safety Office. The Radiation Safety Office will 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.

The Radiation Safety Office 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 the Radiation Safety Office. 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. The Radiation Safety Office 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 the Radiation Safety Office and found to be free of any significant radiation (external radiation levels indistinguishable from background and contamination levels less than 100 dpm/100 cm²). The Radiation Safety Office 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 and/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 Part 20 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

For the purposes of this manual, “shall” denotes a requirement while “should” means a recommended standard.

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 the Radiation Safety Office. The Licensed Investigator must ensure that all radionuclide laboratories under his or her 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 of 10 CFR 20.1001 – 20.2401 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 Nuclear Regulatory Commission regulations 10 CFR 20.

Authorized User: Refers to someone who has been designated by a Licensed Investigator as qualified by virtue of his or her training and experience to use radioactive material or radiation producing equipment in the Licensed Investigator'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: Any radioactive material (except enriched uranium or plutonium) produced by a nuclear reactor. Additionally, it is any material that has been made radioactive through the use of a particle accelerator or any discrete source of radium-226 used for a commercial, medical, or research activity. In addition, the NRC, in consultation with the EPA, DOE, DHS and others, can designate as byproduct material any source of naturally-occurring radioactive material, other than source material, that it determines would pose a threat to public health and safety or the common defense and security of the United States.

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

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

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 a Licensed Investigator or the Radiation Safety Office. Access, occupancy, and working conditions are controlled for radiation protection purposes.

Curie (Ci): A unit of radioactivity (activity). One curie equals 3.7×10^{10} nuclear transformations per second. 1mCi=0.001 Ci, 1 uCi = 0.000001 Ci.

Declared Pregnant Woman: 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: A Licensed Investigator who has permanently suspended his or her 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 (Hd): The external whole-body exposure dose equivalent at a tissue depth of 1 cm (1000 mg/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): A measure of the biological damage from radiation exposure determined by the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

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

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

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

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

Extremity: Hand, elbow, arm below the elbow, foot, knee 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 ($t_{1/2}$): The time required for any given radionuclide to decrease to one-half of its original quantity.

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: A Licensed Investigator who has temporarily suspended his or her 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 the Radiation Safety Office. 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.

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/cm²).

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 his/her experience and training, to possess and use radioactive materials at the University of Connecticut.

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

Licensee: The holder of a NRC license; The University of Connecticut.

License Termination: All radioactive material is permanently transferred to the Radiation Safety Office, 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 the Radiation Safety Office. Licensed Investigators 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. However, an individual is not a member of the public during any period in which the individual receives an occupational dose as an authorized trained radioactive material user.

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 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 (also called a deterministic effect).

Non-User: An individual who is authorized to have unescorted access to a controlled and or restricted areas 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 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 § 35.75, or from voluntary participation in medical research programs.

Quality Factor (Q): The modifying factor (listed in tables 1004(b).1 and 1004(b).2 of 10 CFR Part 20.1004) that is used to derive dose equivalent from absorbed dose.

Rad: A unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/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, radiowaves, 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.

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 area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Roentgen: 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 waste water and refuse, but excluding sewage treatment facilities, septic tanks and leach fields owned or operated by the University.

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

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 ($1 \text{ Sv} = 100 \text{ rem}$).

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): Is the sum of the deep-dose equivalent (external exposures) and the committed effective dose equivalent (for internal exposures).

Transport Index (TI): The transport index, often called the TI, is 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 Licensed Investigator 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

Important Telephone Numbers

RADIATION SAFETY COMMITTEE MEMBERS

	<u>Dept.</u>	<u>Ext.</u>	<u>U-Box</u>
Nathan Alder, Chair	MCB	5154	U-3125
David Grant, Vice Chair	PHARM	4265	U-3092
Rahul Kanadia	PNB	8947	U-3156
James Mahoney	CTI	9299	U-5202
Ji-Young Lee	NUTR SCI	1827	U-4017
Rachel O’Neill	MCB	6031	U-1131
Amy Courchesne, RSO	EHS	5399	U-4097
Wesley Byerly, Ex. Officio, Associate Vice President for Research (Executive Management Representative)	Office of the VP for Research	860-679-6568	U-1006
Teresa Dominguez, Director, EHS, Ex. Officio	EHS	0981	U-4097

RADIATION SAFETY OFFICE PERSONNEL

Radiation Safety Officer (RSO)	Amy Courchesne	(860) 486-5399
Radiation Safety Specialist	Roy Brown	(860) 486-0925
Radiation Safety Senior Specialist	Brianna Sullivan	(860) 486-1108

EHS ADMINISTRATIVE SUPPORT PERSONNEL

EHS Main Office..... (860) 486-3613

OTHER IMPORTANT NUMBERS:

UConn Police Department, Storrs	Emergency	911
	Routine Calls	(860) 486-4800
UConn Fire Department, Storrs	Emergency	911
	Routine Calls	(860) 486-4925
UConn Police Department, Avery Point	Emergency	911
	Routine Calls	(860) 405-9088

APPENDIX B

Responsibilities of the Radiation Safety Office

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 and/or non-ionizing radiation.
2. Establishing procedures for purchasing, receiving and shipping of all radioactive materials coming to or leaving the University of Connecticut.
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 licenses 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 C

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 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 the Radiation Safety Office 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 and/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 the Radiation Safety Office 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.A and Section VI. C.
 - 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 the Radiation Safety Office when requested.
 - e. Ensuring that all radioactive waste materials are disposed in accordance with University procedures, including preparation of radioactive waste for transfer to the Radiation Safety Office for disposal.

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- f. Ensuring that appropriate records of radionuclide usage are maintained and reported to the Radiation Safety Office 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 and/or students.
8. Ensuring that the radiation exposures to service personnel are minimized while working on equipment, hoods, or sinks in radioactive material areas. The Radiation Safety Office 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 Licensed Investigator must make appropriate arrangements for the return to the Radiation Safety Office all radioactive materials, including waste, assigned to them under the license. Particular care should be exercised to see that specialized equipment such as personnel monitoring devices are returned to the Radiation Safety Office.
 10. Notifying the RSO if he/she is to be absent from the University for more than one month. Arrangements shall be made for another Licensed Investigator to take responsibility for the licensed materials and subordinate research staff of the absent LI.

APPENDIX D

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 either remove or report any detected radioactive contamination before leaving the laboratory.
4. Utilizing all appropriate protective measures such as:
 - a. Wearing appropriate personal clothing (e.g. long pants, fully enclosed footwear) as well as proper protective clothing (e.g. gloves and a lab coat) whenever working with radionuclides.
 - 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.
6. Maintaining good personal hygiene. Not working with radioactive materials if there is 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 areas in which radioactive materials are being used (hoods, benches, etc.). Minor contamination should be cleaned up. Large amounts (>10,000 dpm/100cm²) or personal contamination shall be reported to Radiation Safety Office. (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 insure 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 should 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 Office for any emergency repair of contaminated equipment in the laboratory.
11. Reporting accidental inhalation, ingestion or injury involving radioactive materials to the Licensed Investigator and the Radiation Safety Office, and carrying out their recommended corrective measures. The individual shall cooperate in any and all attempts to evaluate his 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 the Radiation Safety Office.

APPENDIX E

Radiation Exposure Limits

OCCUPATIONAL DOSE LIMITS FOR ADULTS

The following are regulatory dose limits 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 reasonably achievable (ALARA)

	Dose Equivalent (Rem/yr)	UConn ALARA Goal (Rem/yr)
Whole Body Dose	5.0	0.5
Individual Organs	50	5.0
Extremities	50	5.0
Skin of Whole Body	50	5.0
Lens of Eye	15	1.5
Declared Pregnant Worker (see note)	0.5/whole body dose/term	
Environmental Release	(See 10 CFR 20 Appendix B)	

The 10 CFR 20 whole body dose limits for the general public are 100 mrem/year and 2.0 mrem in any one hour.

Note:

If a female employee wishes to declare her pregnancy she should inform the University through the Radiation Safety Office, when a pregnancy is confirmed. The University offers the following alternatives during pregnancy:

1. Possible reassignment to activities involving less exposure to radiation.
2. Continue with current assignment, ensuring she does not exceed the above permissible dose for pregnant workers.
3. Take maternity leave in accordance with University regulations.

The Radiation Safety Officer can provide further information regarding the risk of fetal exposure to ionizing radiation.

APPENDIX F

Procedures for Receiving and Opening Radioactive Material Packages

A. RADIATION SAFETY OFFICE

The Radiation Safety Office 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 procedure and notify 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 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 $>100\text{dpm}/100\text{cm}^2$ 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 Office inventory.
7. Deliver radioisotope package to appropriate radioisotope laboratory.

B. AUTHORIZED RADIOACTIVE MATERIAL USER

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

1. Store package in a secure location.
2. Add amount of radioactivity received to the radioisotope inventory.
3. Use the Radiation Safety Office provided Package Receipt Form to document the opening of the received package. Complete and sign the Package Receipt Form.
4. Upon opening of the package take the following precautionary steps:
 - a. Wear protective clothing.
 - b. Open the outer package and remove 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 Package Receipt Form and retain in records.

APPENDIX G

Radioactive Waste Procedures for Laboratories

A. LABORATORY STORAGE

Each Licensed Investigator is responsible for the safe and secure storage of his/her radioactive waste until the Radiation Safety Office picks it up. This means that the waste should be properly secured from unauthorized removal and be stored with sufficient shielding to minimize the radiation exposure to any individual in the laboratory.

Contact the Radiation Safety Office immediately if unauthorized individuals 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 ($t^{1/2} < 120$ days) waste must be separated from the long half-life ($t^{1/2} \geq 120$ 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. 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.

Laboratory personnel are required to use radioactive waste containers provided by the Radiation Safety Office 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 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 Approved Liquid Scintillation Cocktail List which can be found on the EHS website or may be obtained by requesting it from the Radiation Safety Office 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 waste categories could result:

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

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

C. WASTE COLLECTION AND PICK-UP

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 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.

All radioactive waste containers shall be kept in the controlled areas of laboratory, not in the hall or other unsecured area, as this represents a violation of NRC regulations and subjects a Licensed Investigator to revocation of his/her license. 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 the Radiation Safety Office for recommendations concerning proper shielding or different methods for handling waste should be arranged. Lucite rather than lead should be used as the shielding for P-32 waste. If additional shielding is needed use Lucite on the inside of the shield and lead on the outside.

Waste container removal can be requested by going to the EHS website and filling out the on-line pick-up request form. Scheduling a pick up necessitates advance notice;

allowance must be made to anticipate full containers (not over-flowing) at the time of pick up. Licensed Investigators are reminded of their responsibility for safe and secure storage of the waste until removed by the Radiation Safety Office. 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 100 dpm/100 cm². 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.

D. WASTE PROCESSING

The Radiation Safety office 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 and/or State agency.

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 Licensed Investigator 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 uCi/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. Licensed Investigators 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 the Radiation Safety Office.
2. Bags containing animal carcasses and associated waste shall be labeled with the specific radionuclide, date, activity and weight of the containerized carcasses/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 the Radiation Safety Office 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 his/her 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, he/she must attend the official UConn non-user Radiation Safety training. Ancillary personnel (e.g. repair and/or service personnel) must be escorted at all times by trained lab personnel or be provided lab specific training or instruction by the Licensed Investigator or appropriate designee. For the Research Vessel (R/V) Connecticut: At any time when isotopes are on board the ship, visitors to the R/V 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 a Licensed Investigator’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. A Licensed Investigator 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 his or her Protocol.

APPENDIX I

Emergency Procedures

I. EMERGENCY PHONE NUMBERS

Storrs Campus Police:	860-486-4800 (Non-Emergency Incidents) 911 (Emergency)
Storrs Fire Department:	860-486-4925 911 (Emergency)
Avery Point Police:	860-405-9088 (Non-Emergency Incidents) 911 (Emergency)
Radiation Safety Office	860-486-3613

II. EMERGENCY PROCEDURES

This section applies to emergencies involving radiation exposure and/or 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.

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. During normal work hours call the Radiation Safety Office. If the contamination incident is after normal work hours, follow your laboratory's after-hours procedure for handling radiological emergencies. If the situation is of an urgent nature, call the Campus Police (911) after work hours to get outside help and to speak to a member of the Radiation Safety Office and supply the following information:
 - a. Location of accident
 - b. Number of persons 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 Radiation Safety provided spill kit. 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 about 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 the Radiation Safety Office and the Licensed Investigator immediately following decontamination attempts. After hours contact the Campus Police at the 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 him or herself from contamination and from contact with 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. Notify the Radiation Safety Office (if after work hours, Radiation Safety personnel can be reached through the campus police). Follow procedures in Section II, Part A.

III. CAMPUS EMERGENCY RESPONDERS PROCEDURES

- A. The Campus Police/Fire Department upon receiving a call of an incident involving radioactive materials or radiation exposure should collect the following information:
1. Location of incident.
 2. Number of persons involved or injured.
 3. Radionuclide and amount of radioactivity involved.
 4. Type of radiation exposure if applicable.
 5. Name and telephone number of the individual giving the information.
- B. Police/Fire Department dispatch personnel should notify the Radiation Safety Officer or Radiation Safety staff and relay the information. Emergency responders dispatched to the scene, should do the following:
1. If injuries are involved, apply first aid and summon ambulance if appropriate.
 - a. Work with laboratory personnel to determine extent of radioactive contamination. (The survey instruments in the laboratory are best suited for measuring contamination.)
 - b. Remove any contaminated clothing if it can be done without aggravating injury.

2. Keep the Radiation Safety Office informed if they are not already present at the scene.
 3. Obtain the names and addresses of any person who is, or may have been, in the immediate area affected.
 4. When ambulance or rescue squad personnel arrive, they should be informed of the known or suspected presence of radioactive material.
 5. Keep the public away from the incident area. Detour vehicular and pedestrian traffic as for a fire.
 6. Any contaminated individuals should be wrapped in a blanket or other means used to contain the contamination. Call the Windham Memorial Hospital Emergency Room, if necessary, and indicate the number of patients that will be coming.
- C. After UConn Police/Fire 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 the University of Connecticut Radiation Safety personnel or other qualified radiation monitors (e.g. CT DEEP, NRC).

IV. INCIDENT REPORTING

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

APPENDIX J

After Hours Emergency Response Policy

Radiation Safety Office personnel are available to respond to emergencies involving radioactive contamination on campus during normal work hours. If the emergency occurs outside of the normal work hours, the initial response must be provided by laboratory personnel and university first responders, (fire/police), who have been trained by the RSO. The LI is primarily responsible for contamination monitoring 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. 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	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.

*ALI = Annual Limit of Intake is equivalent to an annual whole body dose of 5,000 mrem.
Typical ALI values:

Isotope	0.01ALI (μ Ci)	0.1 ALI (μ Ci)
H-3	800	8000
C-14	20	200
P-32	6	60
S-35	14	140
I-125	0.4	4

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 the Radiation Safety Office and the Licensed Investigator. The LI shall file an incident report with the Radiation Safety Office within 24 hours following the incident. The licensed Investigator also shall show cause to 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 the Radiation Safety Office and the Licensed Investigator shall file an incident report with the Radiation Safety Office within one week following the incident. The Licensed Investigator 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 the Radiation Safety Office 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 and/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. The Radiation Safety Office also may increase its frequency of audits.