KENT STATE UNIVERSITY

Radiation Program Manual

January 2021

1. Introduction

1.1. Purpose

The Kent State University radiation safety program is designed to protect users, colleagues and the general public from exposure to radiation and radioactive materials. The operating philosophy of Kent State University (KSU), Office of Compliance and Risk Management and the Academic Division is to maintain **ALARA** (as Low as Reasonably Achievable). The use of ionizing radiation sources on campus is performed in accordance with state and federal requirements. A copy of the Kent State University radioactive material license, federal and state regulations can be obtained by contacting the KSU Radiation Safety Office. The purpose of this manual is to provide all users of ionizing radiation sources with a guide to regulatory requirements, Kent State University organizational policies, user obligations and radioactive material procedures to assist with the maintenance of the **ALARA** concept. A copy of the Kent State University Radiation Safety Manual (RSM) can be obtained from the Research Safety and Compliance website or from the Office of Research Safety and Compliance.

1.2. Scope

This plan applies to all faculty, staff, and laboratory personnel working with radioactive materials or radiation in an academic and / or research laboratory at Kent State University.

2. Organization and Authority

2.1. Government Regulations and Standards

2.1.1 The use of radioactive materials is governed by licenses issued by the Ohio Department of Health Bureau of Radiation Protection (ODH/BRP) as set forth in Rule 3701-39-50-021 of the Ohio Administrative Code (OAC) and OAC 3701:1-38, 3701:1-40, 3701:1-50 and 3701-39-02.1.

2.1.2 In 1999 the State of Ohio became an agreement state with the Nuclear Regulatory Commission (NRC) and assumed all authority for implementation, inspection, and regulation enforcement and radioactive material licensing and possession.

2.1.3 In accordance with the guides and regulations referred to above, academic institutions are required, as a condition of a license, to operate a radiation safety program.

2.1.4 This Radiation Safety Manual describes how Kent State University will comply with the Ohio Department of Health Bureau of Radiation Protection (ODH/BRP) rules.

2.1.5 Kent State University's license and a description of its radiation safety program are available from the following sources:

2.1.5.1 Radiation Safety Officer (RSO), the Research Safety Office or website Radiation Safety Compliance and Risk Management.

2.2. Administration of the Radiation Safety Program

2.2.1 **Radiation Safety Committee**

2.2.1.1 According to the terms of the license, the government regulates the use, possession, handling and transportation of radioisotopes. The radiation safety committee will be responsible for overseeing and reviewing the radioactive material operations performed at Kent State University. The committee will report its activities and findings to the Associate Vice President, Compliance and Risk Management.

2.2.2 **Committee Membership**

2.2.2.1 The committee includes an authorized user of each type of use permitted by the license, the radiation safety officer, a representative of the nursing service, and a representative of management who is neither an authorized user nor a radiation safety officer. The committee may include other members as appropriate.

2.2.3 **Committee Authorization**

2.2.3.1 The Radiation Safety Committee has the authority to:

2.2.3.2 Establish, approve and review campus and individual safety procedures.

2.2.3.3 Review and investigate cases that involve violation of guidelines and procedures.

2.2.3.4 Recommend to the Associate Vice President of Compliance and Risk Management to suspend authorization for use of radioisotopes and ionizing radiation.

2.2.3.5 The Radiation Safety Committee will serve as a resource authorized users and other personnel that work with or in the vicinity of radioactive materials.

2.3. Radiation Safety Officer (RSO)

2.3.1 The Radiation Safety Officer is appointed by the Associate Vice President of Compliance and Risk Management.

2.3.2 The RSO has been delegated with the authority to prohibit the use of radioactive materials by personnel who do not meet necessary requirements and to terminate operations that do not comply with state regulations or the Kent State University Radiation Administrative Policies or Manual. Delegation of RSO Authority, Connie Hawke, JD, PhD, Associate Vice President Compliance and Risk Management, March 11, 2013)

2.3.3 **Responsibilities**

2.3.3.1 Coordinate or supervise periodic safety evaluations and tests, provision of bioassays, establishment of systems and procedures for receipt, distribution, storage and radioactive material disposal, establishment of internal record keeping systems and procedures as required by law, such as personnel dosimetry reports.

2.3.3.2 Provide training or information to university support services to inform them of the precautions and protocols that must be taken in areas where these materials are utilized.

2.3.3.3 Ensure incoming radioactive materials packages are inspected and checked for leaks.

2.3.3.4 Conduct surface wipe checks in all labs using radioactive materials semiannually.

2.3.3.5 Inspect laboratory working conditions.

2.3.3.6 Approve radioactive material purchase requisitions to ensure license possession limits are not exceeded.

2.3.3.7 Coordinate disposal of radioactive materials.

2.3.3.8 Maintain inventory of radioactive materials on campus.

2.3.3.9 Maintain records of personal occupational exposures, radioactive materials receipts, radioactive material disposal, authorized user wipe tests, periodic wipe checks and laboratory monitoring.

2.3.3.10 Coordinate calibration of survey meters.

2.3.3.11 Coordinate leak testing of sealed sources.

2.3.3.12 Provide initial training to new users.

2.3.3.13 Conduct lab close out inspections that have requested to be returned to normal use for the decommissioning process application.

2.3.3.14 Establish, approve and/or review overall safety procedures and those for individual users.

2.3.3.15 Review and investigate infringement cases of guidelines and procedures.

2.3.3.16 Recommend to the Associate Vice President of Compliance and Risk Management to suspend authorization for use of radioisotopes and ionizing radiation.

2.3.3.17 The Radiation Safety Committee and its members will be available to users as resources to personnel that are authorized to use radioactive materials.

2.4. Authorized Users

2.4.1 **Requirements**

2.4.1.1 Authorized users are full time faculty that have been designated as authorized users on the license.

2.4.1.2 The authorized user is responsible for ensuring safe use of radioactive materials by their radiation workers.

2.4.1.3 Authorized users are also responsible for ensuring that radioactive materials are appropriately secured and stored against unauthorized use. Appropriate radioactive material disposal is also the responsibility of the authorized user.

2.4.1.4 Authorized Users must be listed on the University Radioactive Materials License.

2.4.1.5 Authorized Users must complete annual training requirements.

2.4.1.6 All faculty must complete the training and experience form (Appendix L) to become an authorized user on the license.

2.4.2 **Responsibilities**

2.4.2.1 Implement the KSU Radiation Safety Manual procedures and requirements.

2.4.2.2 Ensure that proper precautions and procedures are used to preserve personnel health and safety.

2.4.2.3 Train radiation workers on emergency procedures.

2.4.2.4 Institute corrective actions made by the Radiation Safety Officer, the Radiation Safety Committee, or the Associate Vice President of Compliance and Risk Management.

2.4.2.5 Verify that individuals working in the laboratories have completed the necessary training programs before beginning to work with radioactive materials.

2.4.2.6 Ensure that all personnel involved in research protocols are included in the personnel monitoring program if applicable.

2.4.2.7 Monitor the ambient conditions of the lab(s) periodically to ensure ALARA is being maintained.

2.4.2.8 Post proper signage and RSO contact information in the room where radioactive materials are used and stored.

2.4.2.9 Proper disposal of radioactive material wastes to eliminate the accumulation of excessive quantities of radioactive material waste in the laboratory.

2.4.2.10 Notify the RSO of any significant changes in techniques or physical facilities.

2.4.2.11 Notify the Radiation Committee Chair of items that need to be scheduled for discussion at the radiation safety committee meetings on their behalf.

2.5. Radiation Workers

2.5.1 Requirements

2.5.2 Undergraduate, graduate, and post-doctoral students as well visiting faculty must complete required trainings before beginning any work with radioactive materials.

2.5.3 All radioactive material users must attend a radiation safety class and pass a written examination. The examination will test the individual's knowledge of the fundamentals of radiation physics, the effects of radiation on living systems, principles and practice of radiation safety, measurement of radioactivity and monitoring techniques, the mathematics and calculations basic to the use and measurement of radioactivity, and local, state, and federal regulations.

2.5.4 All radioactive material users must work under the supervision of one of the authorized users named on the license.

2.5.5 Radioactive material workers will be responsible for setting up and completing their experiments in a safe manner. If unsafe conditions are observed, it is the responsibility of the worker to notify the authorized user or Radiation Safety Officer. Prior to beginning any experiment or procedure with radioactive materials in a restricted area, all personnel should perform dry run testing of the procedure or experiment to identify possible hazards and unexpected outcomes. Fluorescent material or dyes are recommended for dry run testing. Ultraviolet light can be used to survey the area following an experiment to help indicate material contamination in the area.

2.5.6 Visiting faculty who are listed on another NRC license must supply documentation of previous training and experience to use radioactive materials. and comply with all the provisions of this manual.

2.5.7 Past coursework or experience gained on the job will not exempt a student from completing the above requirements.

2.5.8 All radiation workers must complete annual radiation refresher training.

2.6. Ancillary Personnel

2.6.1. Ancillary personnel are personnel that are permitted to enter radioactive material spaces to perform their duties of employment (e.g. security, cleaning, maintenance, etc.)

2.7. Nonradiation Workers

2.7.1 Individuals that work in the vicinity of areas that are permitted for radioactive material use but do not have authorization to worker with these materials.

3. Training

3.1 Initial Training

3.1.1 All new radioactive material users are required to complete training before beginning any work with radioactive materials. The initial training module consists of a course called Radiation Safety which is accessed online through the Collaborative Institutional Training Initiative (CITI Program) website. All individuals must score an 80% or higher to successfully pass the course. After completing the CITI Program module all individuals

must sign up with the KSU Radiation Safety Office to participate in a lecture facilitated by the Radiation Safety Officer which will review and discuss the KSU radiation safety manual and procedures which includes material shipping, monthly wipe test, waste disposal, record keeping, labeling, instrument calibration, incident reporting and the monitoring program. All attendees must get a score of 80% or above to pass.

3.2 Annual Training

3.2.1 All authorized users and radiation workers are required to complete an annual refresher training. The training is accessed through the KSU online learning management system called Flashtrain. The module reviews pertinent information related to radiation topics such as federal and state regulations, and KSU guidelines and procedures. The training topics vary from year to year to ensure review of all radiation safety information. Users are required to complete a test at the conclusion of the training and must score an 80% or higher to successfully pass the module.

3.3 Stockroom Personnel Training

3.3.1 All stockroom personnel are trained on the proper technique to receive radioactive materials from the carrier service. Training is a in person session facilitated by the RSO. A brief exam is administered at the conclusion of the training to ensure that the radioactive material receiving protocol and precautions are understood. A score of 80% must be attained to successfully pass the course.

3.4 Nonradiation Worker Training

3.4.1 All Nonradiation workers are required to complete the Radiation Training for Nonworkers in the KSU online learning management system called Flashtrain. This training will provide a basic understanding of radioactive materials and the precautions that must be taken when working near these areas. A score of 80% must be attained to successfully pass the course.

3.5 Ancillary Personnel Training

3.5.1 All ancillary personnel (e.g. security, cleaning, maintenance, etc.) whose duties require them to enter radioactive material spaces will be briefed by memo or group meetings as needed by the RSO.

3.5.2 This briefing will include a notice that includes a list of active radioactive material use spaces. Prior to any maintenance being performed in radioactive material spaces, it is KSU policy that the lab must be prepared for maintenance by the lab personnel prior to ancillary personnel entry.

The RSO will review the space after preparation but prior to maintenance to survey the area to ensure radiation exposure is As Low As Reasonably possible (ALARA).

4. Radioactive Material Rules and Requirements

4.1. Radiation Exposure Control and Monitoring

4.1.1. Area Definition

4.1.1.1. **Unrestricted Areas -** are designated as areas in which continual individual presence will yield exposure that equates to less than 2 mRem in any 1 hour (e.g. Halls, Offices, Non-Radiation Labs etc.). There are no control measures needed for exposure from external radiation.

4.1.1.2. **Restricted Radiation Areas** – are areas that are designated radioactive material usage or storage and could potentially result in a dose that could exceed the maximum allowable limits for unrestricted areas.

4.1.1.3. All space or portion of spaces in which radioactive materials or radiation producing equipment are used must be specifically approved for that purpose. Approval for use will is required by the Radiation Safety Officer (RSO).

4.1.1.4. All spaces will be evaluated on the following criterial for approval by the RSO. Factors that will be considered include type of isotope, maximum expected activity, isotope volatility, dispensing methods and the personnel procedures. Additional factors that will be considered are benchtop space, engineering controls such chemical fume hood, biosafety cabinets, shielding, storage space and waste handling facilities.

4.1.1.5. All radioactive materials within the area must be secured from unauthorized removal unless under direct and constant supervision. This means that if the radioactive materials are not under 'direct and constant supervision", they must be locked in suitable enclosures or all doors entering the area must be kept locked.

4.1.1.6. Portions of spaces that are designated as restricted areas are only to be used for radioactive materials use.

4.1.1.7. Before a restricted area in a space can be used for non-radioactive materials use, it must be decommissioned.

4.1.1.7.1. **Restricted Radiation Areas:**

- **Cunningham Annex** - Department of Biological Sciences
- **Integrated Sciences Building** - Department of Chemistry and Biochemistry
- **The Science Research Building**- Department of Chemistry and Biochemistry and Department of Physics
- **Smith Hall** - Department of Physics
- **Williams Hall** - Department of Chemistry and Biochemistry

4.2. Signage and Labels

4.2.1. The door to each room in which licensed materials are used or stored will be posted with a sign bearing the radiation symbol and the words "**CAUTION RADIOACTIVE MATERIALS**" or "**DANGER RADIOACTIVE MATERIALS.**"

4.2.2. The area within laboratories in which radioactive materials are used will be delineated and labeled with a signs or tape with the radiation symbol and the words "**CAUTION RADIATION AREA**." A room or area or sign is not required if a sealed source is present, , provided the radiation level 12 inches from the surface of the source container or housing does not exceed 5 millirem per hour.

4.2.3. A label with the radiation symbol and the words "**CAUTION RADIOACTIVE MATERIAL**" is required on any container used to transport, store or use radioactive materials.

4.2.4. The door to the Iodination Room will be posted with a sign bearing the radiation symbol and words indicating that it is a "**RESTRICTED AREA**."

4.2.5. Emergency Procedures and phone numbers of the RSO and principal investigator will be posted in all radioisotope use areas.

4.3. Personnel Film Badge Program

4.3.1. KSU contracts with an appropriate firm to provide radiation film badges quarterly for radiation users. Personnel are provided with a "whole body" dosimeter badge. Ring or wrist badges are available for situations in which band exposures may be excessively high compared to whole body exposures. This estimated dose is reported quarterly to the Radiation

Safety Office. The Radiation Safety Officer then notifies those individuals who have received more than minimal exposure.

4.3.2. **Film Badge Requirements**

4.3.2.1. OAC 3701:1-38-14 (B) only requires workers to wear film badges if their exposure exceeds 10% of the allowable year dose which is 500 mR. Workers in areas where isotopes are handled and not exposed above cited levels may choose to wear film badges but are not required too.

4.3.2.2. Film badge monitoring for 20 years or more have yield less than 100 mR. for each year of individual monitoring.

4.3.3. **Exposure Limits**

4.3.3.1. No individual over 18 years of age will receive an occupational dose from any radiation source in one year in excess of the following:

4.3.3.2. Whole body (head, trunk and active blood forming organs): **5 rem (0.05 Sv)**

4.3.3.3. Total Effective Dose Equivalent

4.3.3.4. Lens of eye: **15 rem (.15 Sv)**

4.3.3.5. Skin of whole body and extremities: **50 rem (.5 Sv)**

4.3.3.6. Persons under 18 years of age are limited to maximum exposures of 1/10th of the above levels.

4.3.3.7. Declared pregnant woman are limited to a maximum exposure of 500 mrem/9 month gestation period per OAC 3710:1-38-01.

4.3.3.8. Exposure to the general public (non-occupational) is limited to maximum levels of 100 mrem/year.

4.3.3.9. Planned Special Exposures have special government regulations must be utilized if higher exposures are anticipated. These procedures or experiments must be performed under the direct supervision of the Radiation Safety Officer. Contact the RSO for information regarding planned special exposure experiments or procedures.

4.4. Bioassay Program

4.4.1. The Bioassay will be performed using the U.S. NRC guidelines for individuals who handle large quantities of tritium (**3H**) labeled compounds and/or large quantities of **125I** or **131I** labeled compounds. See Appendix F for summary of requirements.

4.4.2. Bioassays are performed on an "as needed" basis.

5. Monitoring and Documentation

5.1 Laboratory Monitoring Program

5.1.1 Laboratory monitoring will be performed using survey meters and surface wipe tests.

5.1.2 Each Authorized User is required to monitor all radioactive material rooms under their supervision.

5.1.3 Radiation levels will be monitored using a survey meter during isotope operations.

5.1.4 Surface wipe testing will be conducted at least once a month when radioactive materials are used, and the results will be reported to the RSO.

5.1.5 Authorized users and radiation workers should focus on frequently touched areas during collection of surface wipe samples. Areas of focus should be benchtop surfaces, hood aprons, window handles, door handles, cabinet handles, sash handles, furniture, equipment and floors. Areas can be wiped with filter paper or cotton swab. The surface area that is sampled should be approximately 100 square centimeters. The amount of radioactivity will be determined using the liquid scintillation counter program.

5.1.6 A blank sample must always be included in the wipe test when using the scintillation counter.

5.1.7 Surface wipes are not required for areas that only use sealed sources.

5.2 Surface Decontamination

5.2.1 Wipe test results that exceed the blank by 200 dpm or more must be decontaminated.

5.2.2 Survey meter readings that are greater than background by a factor of 10x must be decontaminated.

5.2.3 Refer to Section H.4 for bodily contamination procedures

5.2.4 Refer to Section H.2 for contamination greater than 1 uCi.

5.2.5 Contaminated areas that are less than 1 uCi, can be decontaminated using a strong detergent (e.g., Isoclean or Radwash) and warm water. The wash and rinse water can be disposed of down the drain. The surface must be rubbed dry with paper towels, and these towels must be discarded as radioactive waste.

5.2.6 After decontamination, the area must be monitored again, and, if contamination persists, the decontamination procedure must be repeated until the contamination level is less than 200 dpm or 10x background.

5.3 Monthly Report

5.3.1 All authorized users must submit a monthly report (Report Form, Appendix O) for all the spaces under their authority. Monthly reports must be submitted the Radiation Safety Officer (RSO) by the 10th day of the following the month. The reports must list the monitoring date and instrument, test results for surveys in mR/h or disintegrations per minute (dpm) for surface wipes, surface locations, individual conducting the monitoring, raw data report for surface wipes and any corrective action taken. These reports will be kept on file by the Radiation Safety Officer.

5.4 Leak Test

5.4.1 Sealed sources containing licensed material (not **3H**) with a half-life greater than 30 days must be tested for contamination and / or leakage before use (gaseous forms are excluded). Subsequently, each source must be tested at least once every 6 months, unless it contains less than 100 microcuries of beta and/or gamma emitting materials or less than 10 microcuries of alpha emitting material.

5.4.2 Sealed sources on the material license that require a regular leak test are:

5.4.2.1 The 39 Plutonium encapsulated as a Pu Be neutron source (AEC #N320B90; original activity: 2 Ci) located in Smith Hall, room 203E

5.4.3 The wipe test for the sealed source listed above is conducted under the direct supervision of the authorized user.

5.4.4 Commercially available wipe test kits with analysis performed by an independent lab are used to assess contamination.

5.4.5 The results from the wipe test reports are kept by authorized user, and a copy is sent to the RSO.

6. Purchasing and Receiving Procedures

6.1. Radioactive Material Procurement

6.1.1 All purchase requisitions for radioactive materials must be approved by the Radiation Safety Officer or his designee, regardless of the type or quantity of radioactive materials being ordered. Once a requisition is received, the Radiation Safety Officer will examine the current inventory and verify that receipt of the material ordered will not exceed the possession limit for that isotope. The Radiation Safety Officer will file a copy of the signed and dated purchase requisition and forward the original to the Department for processing.

6.1.2 A request to purchase radioactive materials will only be granted if the RSO has current wipe test results, isotope usage log and all annual training is completed.

6.2. Radioactive Material Receipt

6.2.1 Only radioactive materials that have been ordered through the Radiation Safety Office will be delivered. Any materials not ordered through the Radiation Safety Office will be returned to the sender unopened.

6.2.2 Radioactive material packages are delivered to the Cunningham Hall Stockroom. Trained stockroom personnel sign for the package and then immediately notify the Radiation Safety Officer (RSO) or designee of delivery. If the RSO determines that the package is damaged to the degree that radioactive material may have contaminated its surface, the Radiation Safety Officer will contact the manufacturer immediately. The Radiation Safety Officer will then inspect the package, the receiving area, and all personnel that handled the package to determine the extent of possible contamination. The carrier will be notified of possible contamination and instructed to return to campus to determine if the carrier and / or the vehicle has been contaminated.

6.2.3 Packages that are received in good condition will be inspected by the RSO. The inspection is documented using the form in Appendix G. Package inspections will be performed using a survey meter and / or surface wipe tests (inspections are exempted for quantities that are considered non-exempt). Material inspection will include monitoring of the outside and inside of the corrugated packaging along with the isotope container and documented using the form in Appendix N. The material quantity is added to the CEMS radioactive material database.

6.3. Radioactive Material Inventory

6.3.1 The Radiation Safety Officer maintains the radioactive material inventory records for the campus to ensure that each isotope possession limit is not exceeded.

6.3.2 Authorized users are responsible for maintaining their radioactive material receipt records and usage and disposal logs for the rooms under their supervision.

6.3.3 At the beginning of each calendar month, the Radiation Safety Officer notifies each licensee to submit a radioactive material usage log and wipe test results from the previous month by the 10th day of that month. The Radiation Safety Officer enters the monthly activity for each isotope into the CEMS system which calculates the remaining activity for each isotope that was received and used in the previous month.

6.3.4 All material transfers between authorized users must be approved by the RSO. The amount of activity transferred must be noted on both the receiver and donor radioactive material usage logs.

6.3.5 Each calendar month, the RSO will compare the total activity present on campus (both in rooms and in waste drums) with the possession limit for each specific isotope. If the total present on campus exceeds 90% of the possession limit, all authorized users will be notified. Under this circumstance the Radiation Safety Officer may consider requesting an amendment from the State of Ohio to increase possession limits or schedule a isotope waste pickup by a third party waste hauler.

7. Storage and Use

7.1. Radioactive Material Storage Requirements

7.1.1 All radioactive materials must be stored in a controlled area that restricts access to only authorized personnel to prevent unauthorized removal and/or use of the material.

7.1.2 The authorized user or radiation worker must keep all radioactive materials under direct observation at all times. Radioactive materials must never be left unattended. Materials must be returned to locked storage or doors must be locked if personnel must leave the room.

7.1.3 Radioactive materials that are stored in uncontrolled areas (e.g. hallway refrigerator or freezer), must be locked to restrict unauthorized access or removal.

7.1.4 All containers, storage, equipment, and / or instruments (e.g. vials, columns, glassware, pipettes, chemical fume hoods, shields etc.)that are used for radioactive material work must be marked with an approved label bearing the words "**Radioactive Materia**l". Materials or containers used in common use facilities must also contain the personnel name (in English) and lab number.

7.2. Radioactive Material Use Requirements

7.1.5 All radioactive materials can only be used in designated Restricted Radiation Areas. Radioactive material are hazardous substances and safe practices must be incorporated into procedures and experiments.

7.1.6 No eating, drinking, or application of cosmetics in any areas where radioactive material is used or stored.

7.1.7 Pipetting radioactive materials by mouth is prohibited.

7.1.8 Food or drink, even in sealed containers, cannot be stored in any room where radioactive materials are used or stored.

7.1.9 Laboratory coats, safety glasses or goggles, disposable gloves and closed toed shoes must be worn at all times while handling radioactive materials.

7.1.10 Monitor hands, clothing and shoes for contamination using a survey meter after each procedure and before leaving the area.

7.1.11 Always wear appropriate personnel monitoring devices (if applicable) at all times while in areas where radioactive materials are used or stored.

7.1.12 Finger badges should be worn when handling one millicurie or greater of **32P** or other energetic beta emitters.

7.1.13 Dispose of radioactive material waste in designated receptacles only.

7.1.14 Cover containers that contain radioactive material solutions. Label container with compound name, radionuclide, date, and activity.

7.1.15 Transport all radioactive materials in shielded containers.

7.1.16 Use shielding when working with radioactive materials in the lab.

7.1.17 Disposable clothing should be worn in the event of a major spill.

7.1.18 Glassware, tongs, pipettes, and other similar tools used in a radiation area should be marked and not used in a non-radiation area. Contaminated glassware should be disposed of or washed promptly.

7.1.19 Confine material work to a small area to limit contamination in the event of spill.

7.1.20 Experiments or procedures that may produce aerosols must be performed in a chemical fume hood, glove box or similar protective device.

7.1.21 Cover work surfaces with an absorbent paper that contains waterproof lining or use trays with side walls to contain material spillage. Absorbent paper should be changed after each use and trays should be washed after each use to prevent the spread of radioactive contamination.

7.1.22 Monitor the area with a survey meter before, during, and after an experiment to detect contamination.

7.1.23 Minimize exposure from gamma and high energy beta emitting radioisotopes by shortening the length of work time when working with large amounts of radioactivity. Confine these large quantities of isotopes to a lead storage box or lead pig in a isolated area of the laboratory (e.g., back corner of a hood or refrigerator). Use long handled forceps or tongs if possible, to reduce exposures.

7.3. Administrative Hold

7.3.1. An administrative hold is a voluntary action by an authorized user, to temporarily stop all radioactive material research activities. Administrative holds are not considered suspensions or terminations, and do not meet reporting requirements to the Ohio Department of Health/Bureau of Radiation Protection (ODH/BRP) or other federal or state agencies.

7.3.2. Administrative Hold request must be submitted to the RSO in writing.

7.3.3. Before an administrative hold will be approved by the radiation safety office all radioactive materials will be removed from the lab and a wipe test will be conducted to ensure ALARA is achieved.

7.3.4. The authorized user will remain on the license but cannot acquire any or use any radioactive materials until the radiation safety committee has approved the use of the radioactive material protocol and a lab review has been conducted by the radiation safety officer.

7.3.5. During this period the Authorized User will not be required to submit monthly reports.

7.4. Termination of Radioactive Material Use

7.4.1. Authorized User privileges can be terminated by the RSO if an authorized user is found to be in violation of any KSU requirements, federal, state or local regulations.

7.4.2. All violations will be reported to the State of Ohio Department of Health Bureau of Radiation Protection and University Administration.

8. Transportation and Disposal

8.1. Off Campus Transportation

8.1.1. Limited quantities of radioactive materials may be transported off campus to another facility licensed by the State to receive radioactive materials. Due to the numerous State, NRC and DOT regulations governing transportation of these materials on public highways, **ALL MATERIAL TRANSPORTATION OFF CAMPUS MUST BE SCHEDULED THROUGH THE RADIATION SAFETY OFFICE.**

8.2. Radioactive Material Waste Storage and Disposal

8.2.1. Radioactive material waste are only stored in restricted areas approved by the Radiation Officer. Cunningham Annex Room A-013 is the approved room to store radioactive materials waste to decay in storage. Refer to the Kent State University Proper Segregation, Minimization and Disposal of Radioactive Wastes (Appendix K.) for more details.

8.2.2. Records will be kept in compliance with OAC 3701:1-38-20 (K) and OAC 3701:1-39-19 (e) (3).

8.2.3. All liquid waste disposal will be performed by the Radiation Safety Officer in accordance with the limits specified in OAC 3701:1-38-12, Appendix C, Table III, provided the wastes are readily soluble or dispersible in water. Sink waste disposal will be followed by a 5 minute water flushing in the sink in Cunningham Annex A-204. A log will be maintained by the RSO that notes the date, amount, and activity.

8.2.4. Inorganic, biodegradable, and water soluble liquid scintillation cocktails (LSF) may be disposed of down the designated sink as long as they meet the criteria referenced above.

8.2.5. There are three different categories of liquid scintillation vials, disposal requirements are listed below for each.

8.2.5.1. Deregulated vials with nonhazardous contents: vials containing only 3-H and/or 14 C, at 0.05 uCi/gram or less, and prepared with liquid scintillation cocktails identified by the EPA as not appearing to be hazardous wastes.

8.2.5.2. Deregulated vials with hazardous contents: vials containing only 3 H and/or 14 C, at 0.05 uCi/gram or less, and prepared with liquid scintillation cocktails identified by the EPA as hazardous wastes.

8.2.5.3. Radioactive vials which contain more than 0.05 uCi/gram of 3 H or 14-C, and vials containing other radioisotopes.

8.2.5.4. Deregulated vials containing nonhazardous materials may be emptied in the sink, rinsed, and disposed of as regular trash. Deregulated vials containing hazardous materials or are radioactive must be disposed of in separate drums.

8.2.6. Organic liquid scintillation cocktails are not permitted to be used at Kent State University. Organic radioactive liquids that are generated as part of an experiment should be avoided. If generated, they must be disposed of as radioactive and chemical hazardous waste. Short lived and long lived organic liquid wastes must be separated.

8.2.7. Liquid waste containing isotopes will be held for decay-in-storage per OAC 3701:1-38-19(E) in the Hazardous Waste Storage Area. After 10 half-lives the waste will be disposed of as chemical hazardous waste.

8.2.8. **Solid Wastes**

8.2.8.1. Solid Waste should be screened so that only radioactive waste are included in the disposal.

8.2.8.2. Solid waste containing isotopes will be held for decay-in-storage per OAC 3701:1-38-19(E) in the Hazardous Waste Storage Area. After 10 half-lives the waste will be disposed of as chemical hazardous or as normal trash after the radioactive label has been removed and the radiation level has been verified to be at background. Beta and gamma emitters average surface contamination levels should be at background with removable levels at background. The RSO or designee is the ONLY personnel permitted to dispose of decay in storage waste.

8.2.9. The term "radioactive waste" includes all wastes that contain, or are contaminated with, any radioactive material used in the laboratory. This includes liquids, solids, trash, and used scintillation counting liquids, etc. Waste and trash which are not radioactive should never be mixed with radioactive waste. All wastes must be classified and disposed of accordingly.

8.2.10. Needles, scalpels, and any other sharp objects must be packaged separately.

8.2.11. Radioactive materials are not permitted to be used in animals at Kent State University.

8.2.12. Waste containing biological, pathogenic, or infectious material (syringes, test tubes, capillary tubes, etc.) must be autoclaved prior to packaging to render it nonpathogenic.

9. Emergency Procedures

9.1. Low Level Spills

9.1.1. **Low Level Spills**

9.1.1.1. A low level spill is one that is confined to a limited area and the total quantity of material spilled is less than 1 mCi.

9.1.2. Notify the Authorized User Radiation Safety Officer immediately. Cleanup, decontamination and waste disposal will be performed immediately under the direction of the authorized user.

9.1.3. **Spill Containment Process**

9.1.3.1. **NOTIFY**: Notify persons in the area that a spill has occurred.

9.1.3.2. **PREVENT THE SPREAD**: Cover the spill with absorbent paper.

9.1.3.3. **MARK OFF THE AREA**: Do not allow anyone to leave the area without being monitored.

9.1.3.4. **CLEAN UP**: Use disposable gloves and remote handling tongs. Normal cleaning agents should be adequate or use "Count Off". Keep cleaning supplies to a minimum. Proceed from the outermost edges of the contaminated area inward. Place cleaning materials into a plastic bag and dispose of in the radioactive waste container. Also put into the plastic bag all other contaminated materials such as disposable gloves.

9.1.3.5. **SURVEY**: With a low range, thin window GM survey meter, check the area around the spill, hands, and clothing for contamination.

9.1.4. Benchtop spills can be contained by collecting the absorbent paper and placing it in a plastic bag. Label the bag with date, isotope, activity, authorized user, building and room number. The RSO or designee will collect the waste and dispose of it in the appropriate radioactive waste drum.

9.1.5. Surface spills should be cleaned up with a decontamination solution. The rinse water will be collected in a container and handled by the RSO or designee.

9.1.6. Clean the surrounding area with decontamination solution.

9.1.7. After decontamination techniques have been completed, the area must be monitored with a survey meter and surface wipes. If contamination is still apparent, then decontamination procedures must be repeated until detectable radiation levels are as low as reasonably achievable (ALARA).

9.1.8. The Authorized User must submit Radioactive Contamination Report to the Radiation Safety Officer within 7 days. The report will be retained in the Radiation Safety Office.

9.2. Large Spills

9.2.1. **Large Spills**

9.2.1.1. A large spill has is a spill in which the quantity is greater than 1 mCi.

9.2.1.2. **NOTIFY THE RADIATION SAFETY OFFICER OR DESIGNEE IMMEDIATELY**.

9.2.1.3. **CLEAR THE AREA**: Notify all individuals in the area to vacate the room.

9.2.1.4. **PREVENT THE SPREAD**: Cover the spill with absorbent pads, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spread.

9.2.1.5. **SHIELD THE SOURCE**: If possible, contain the spill with shielding but only if it can be done without further contamination or without significantly increasing your radiation exposure.

9.2.1.6. **CLOSE THE ROOM**: Leave the room and lock the door(s) to prevent entry. The Radiation Safety Officer will determine the extent of the spill using a survey meter and surface wipes of the surrounding area. The contaminated area will be labeled with tape and cordoned off to prevent inadvertent entry into the area. Only radiation safety personnel and the authorized user may enter the area until the decontamination procedures are completed.

9.2.1.7. The Radiation Safety Office is responsible for directing the decontamination process to achieve **ALARA**. The Authorized User will be responsible for promptly executing the decontamination procedures deemed necessary by the Radiation Safety Officer.

9.2.1.8. The Radiation Safety Officer and the Authorized User will complete a Radioactive Contamination Report. The Radiation

Safety Committee will be convened to determine corrective measures to prevent future spills of this magnitude.

9.2.1.9. Reports to the State of Ohio will be made per OAC 3701-1-38-21 by the RSO.

9.2.2. **Personnel Contamination**:

9.2.2.1. **Contaminated Clothing**

9.2.2.2. Contaminated clothing should be removed and placed in a hazardous waste for evaluation by the Radiation Safety Officer. If skin contamination has occurred flush the affected area with water and then was with a mild soap and lukewarm water.

9.2.3.1. **External Bodily Contamination**

9.2.3.2. If body surface contact (e.g. arms, legs, hands, fingers etc.) with radioactive materials has occurred then flush the affected area with water. Once the area has been flush, apply decontamination products such D Con or Radwash and then wash with a mild soap and lukewarm water.

9.2.3.3. DO NOT USE HARD OR CAUSTIC SOAPS.

9.2.3.4. DO NOT SCRUB THE AREA WITH AN ABRASIVE TOOL (e.g., SCRUB BRUSH).

9.2.3.5. AVOID PROCEDURES THAT MAY BREAK THE SKIN CAUSING POTENTIAL TRANSFER OF MATERIAL INTERNALLY.

9.2.3.6. External body contamination that exceeds 10,000 dpm or involves a chemical that can be readily absorbed or yields a dose greater than 500 mR will be evaluated by the RSO to determine if decontamination on site can be accomplished or whether the individual should proceed to the nearest hospital emergency room.

9.2.3.7. Onsite decontamination is carried out under the direction of the Radiation Safety Officer and will require a urinalysis bioassay to assess whether the individual can be decontaminated. Once the results

have been evaluated the Radiation Safety Officer will complete the Radioactive Contamination Report.

9.2.4.1. **Internal Bodily Contamination**

9.2.4.2. Individuals that have ingested or have been injected with radioactive materials must be reported to the Radiation Safety Officer or designee immediately. The individual will be transported to the nearest Hospital Emergency Room.

9.2.5.1. **Bodily Contamination Limits**

9.2.5.2. The maximum limits suggested for fixed contamination on hands, body surfaces, personnel clothing and shoes are 200 dpm /100 cm2 (alpha activity) and 0.2 mrad/hr. at 2 cm (beta gamma activity).

9.3. Decommission and Return to Normal Use Procedures

9.3.1. For areas or equipment to be returned to general use, or for equipment to be sent out for maintenance, activity levels must be below those specified in the NRC document "Guidelines for Decontamination of Facilities & Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material", 1987. For ß and g emitters average surface contamination levels should be below 5,000 dpm/ 100 cm2 with removable levels less than 1,000 dpm/ 100 cm2.

9.3.2. The Radiation Safety Officer must be informed prior to the termination of any use of radioisotopes. Areas which are planned to be returned to general, unrestricted use, must have a final survey by the RSO with the results sent to the Decommissioning Group of the Ohio Bureau of Radiation Protection per OAC 1-40-18 (C) (2). Laboratory areas and equipment (including hoods, sinks, refrigerators, freezers, centrifuges, glassware, shielding, storage containers, benchtops, cabinets, and floors) shall be decontaminated or disposed of by the terminating user to the acceptance and approval of the RSO. Equipment and areas which have been cleared will have radioactive materials labels and stickers removed prior to release from the laboratory or disposal to public disposal facilities. When the laboratory is free of all radioactive materials and equipment and all work areas are decontaminated then the Radioactive Materials signs will be removed from the laboratory entrances. Documentation of decontamination surveys and laboratory clearance will remain on file at the Radiation Safety Office for a period of five years.

9.3.3. Preventative Maintenance

9.3.3.1. For all laboratory equipment that utilizes hazardous materials or chemicals routine service should be performed to ensure it operates as designed. This will minimize equipment issues, malfunction or failure.

9.3.4. Housekeeping

9.3.4.1. All laboratories should maintain a clean and clutter free environment to reduce the risk of exposure, injuries and accidents in the laboratory.

9.3.5. Signage

9.3.5.1. All laboratories are required to post a laboratory entrance door sign that displays the lab owner contact information, hazards, personal protective equipment requirements, emergency response information and special hazards and fire hazard information. Contact EHS at 2-4347 to get sign template information.

9.3.5.2. Walls and floor signs should be posted to communicate hazards, equipment and conditions that could potentially lead to an exposure, injury, or incident.

9.3.6. Labeling

9.3.6.1. All primary containers must be labeled according to GHS requirements. This includes the signal word, pictograms, manufacturer information, precautionary statement, hazard statement and chemical name.

a. Signal word indicates hazard level. "Danger" is used for the most severe instances, while "Warning" is less severe.

b. Pictograms identify hazardous products grouped by chemical, physical, health and environmental risk.

c. Manufacturer information identifies the company name, address and telephone number.

d. Precautionary statement describe general preventive, response, storage or disposal precautions. These statements are found on the chemical's safety data sheet (SDS).

e. The hazard statement describes the nature of the hazardous product and the degree of the hazard. These

statements are found on the chemical's safety data sheet (SDS).

f. Chemical name identifies the product.

9.3.6.2. The primary container label must not be removed or defaced until the container is empty. If the manufacturer label is damaged or becomes illegible, then the container should be relabeled with the according to GHS requirements.

9.3.6.3. All primary containers must be labeled with a barcode to identify that chemical in the chemical inventory system.

9.3.6.4. All secondary containers must be labeled with the chemical name (in English), signal word, hazard statement, pictograms and date of transfer or preparation.

9.3.6.5. All primary containers must be labeled with a barcode to identify that chemical in the chemical inventory system.

9.3.6.6. All primary and secondary containers that are stored in common use storage areas such as refrigerators, flammable cabinets, corrosive cabinets, and chemical storage rooms must have the lab worker's name on the container.

9.4. Radioisotope Use Application Process

9.4.1. No person may use, or bring into an official part of KSU, radioisotopes in any amount without notification of the Radiation Safety Officer.

9.4.2. Authorization for holding and using radioisotopes is given to designated individuals, known as Authorized Users, (PI's or Users) who must be full time faculty members. They are a responsible for safe use, storage and disposal of all radioisotopes under their jurisdiction.

9.4.3. Applications for the initial use, or modification of existing authorizations, of radioisotopes must be submitted in writing to the Radiation Safety Officer who may approve the use on an interim basis (App. O). The RSO will forward the proposal with comments and recommendations to the Ohio Department Of Health for approval and amendment to the license.

9.4.4. The Authorized User is responsible for providing written guidelines and analytical procedures for handling specific isotopes used.

9.4.5. Authorization and Permits for use will be effective for a 5 year period and will cover specified radioisotopes and their quantities. University purchasing offices will honor only those requests from Authorized User whose names appear on the list of authorized users received from the Radiation Safety Officer. All radioisotope purchase orders are approved

by the Radiation Safety Officer to ensure that the order is within University and laboratory inventory limits.

Appendix A

Glossary of Terms

1. **ABBREVIATIONS**: RSC - Radiation Safety Committee; RSO - Radiation Safety Officer; RSM - Radiation Safety Manual.
2. **ABSORPTION**: The phenomenon by which radiation imparts some or all of its energy to any material through which it passes.
3. **ALARA**: (As Low as Reasonably Achievable) Making every reasonable effort to maintain exposures to radiation as far below the NRC specified dose limits as is practical consistent with the purpose for which the licensed activity undertaken.
4. **ALI:** (Annual Limit on Intake) The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year that would result in a committed effective dose equivalent of 5 rem (0.05Sv) or a committed dose equivalent of 50 rem (0.5Sv) to any individual organ or tissue.
5. **ALPHA PARTICLE**: A strongly ionizing particle emitted from the nucleus during radioactive decay having a mass and charge equal in magnitude to a helium nucleus, consisting of 2 protons and 2 neutrons with a double positive charge.
6. **ANNIHILATION** (Electron): An interaction between a positive and negative electron; their energy, including rest energy, being converted into electromagnetic radiation (annihilation radiation).
7. **ATOM**: Smallest particle of an element which is capable of entering into a chemical reaction.
8. **AUTORADIOGRAPH**: Record of radiation from radioactive material in an object, made by placing the object in close proximity to a photographic emulsion.
9. **BACKGROUND RADIATION**: Ionizing radiation arising from radioactive materials other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in the building material itself, etc.
10. **BEQUEREL (Bq)**: The SI unit of activity in disintegrations per second (s-1). (1 Ci=3.7E10 Bq).
11. **BETA PARTICLE**: Charged particles emitted from the nucleus of an atom, having a

mass equal in magnitude to that of the electron, and a single positive or negative charge.

12. **BREMSSTRAHLUNG**: Electromagnetic (x-ray) radiation associated with the deceleration of charged particles passing through matter. Usually associated with energetic beta emitters, e.g. phosphorus-32.

13. **CALIBRATION**: Determination of accuracy or variation from standard of a measuring instrument to ascertain necessary correction factors.

14. **CARRIER FREE**: An adjective applied to one or more radionuclides of an element in minute quantity, essentially undiluted with stable isotope carrier.

15. **COMMITTED DOSE EQUIVALENT (HT,50)**: The dose equivalent to tissue or organs of reference (T) that will be received from an intake of radioactive material by an individual during the 50 year period following the intake.

16. **COMMITTED EFFECTIVE DOSE EQUIVALENT (HE,50)**: The sum of the products of the weighting factors applicable to the body organs or tissues that are irradiated and the committed dose equivalent to the tissues or organs.

17. **CONTAMINATION, RADIOACTIVE**: Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful. Contaminations may negate the validity of an experiment, as well as being a source of internal or external radiation exposure.

18. **COUNT (RADIATION MEASUREMENTS)**: The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse. (See Efficiency).

19. **CRITICAL ORGAN**: The organ or tissue, the irradiation of which will result in the greatest hazard to health of the individual or his descendants.

20. **CURIE**: The quantity of any radioactive material in which the number of disintegrations is 3.7000E10 per second. Abbreviated Ci. Millicurie: One-Thousandth of a curie (3.7E7 disintegrations per second or 2.22E12 disintegrations per minute). Abbreviated mCi. (See Becquerel).

21. **DAC:** (Derived Air Concentration) The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2000 hours under conditions of light work, results in an intake of one ALI

22. **DECAY, RADIOACTIVE**: Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

23. **DEEP DOSE EQUIVALENT (Hd)**: External whole body exposure, the dose equivalent at a tissue depth of 1 cm (1000 mg/cm2).

24. **DOSE**: A general term denoting the quantity of radiation or energy absorbed in a specified mass. For special purposes it must be appropriately qualified, e.g. absorbed dose.

25. **DOSE ABSORBED**: The energy imparted to matter by ionizing radiation per unit

mass of irradiated material at the place of interest. The unit of absorbed dose is the rad (62.4 x 106 MeV/g or the gray (1 J/kg).

26. **DOSE EQUIVALENT**: A quantity used in radiation protection expressing all radiation on a common scale for calculating the effective absorbed dose. The unit of dose equivalent is the rem, which is numerically equal to the absorbed dose in rads multiplied by certain modifying factors such as the quality factor, the distribution factor, etc. (See Sievert)

27. **EFFICIENCY (COUNTERS)**: A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably so it is well to make sure which factors (window, transmission, sensitive volume, energy dependence, etc.) are included in a given case.

28. **ELECTRON**: Negatively charged elementary particle which is a constituent of every neutral atom. Its quantity of negative charge equals 1.6 x 10-19 coulombs. Its mass is .000549 atomic mass units.

29. **ELECTRON CAPTURE**: A mode of radioactive decay involving the capture of an orbital electron by its nucleus. Capture from a particular electron shell is designated a "K-electron capture," "L-electron capture," etc.

30. **ELECTRON VOLT**: A unit of energy equivalent to the amount of energy gained by an electron in passing through a potential difference of 1 volt. Abbreviated eV. Larger multiple units of the electron volt frequently used are: keV for thousand electron volts, MeV for million electron volts and GeV for billion election volts.

31. **ERYTHEMA**: An abnormal reddening of the skin due to distention of the capillaries with blood. It can be caused by many different agents - heat, drugs, ultra-violet rays, ionizing radiation.

32. **FILM BADGE**: A packet of photographic film used for the approximate measurement of external radiation exposure for personnel monitoring purposes. The badge may contain one or more films of differing sensitivity, and it may contain filters which shield parts of the film from certain types of radiation.

33. **GAMMA RAY**: Very penetrating electromagnetic radiation of nuclear origin. Except for origin, identical to x-ray. (See Photon)

34. **GEIGER-MUELLER (GM) COUNTER**: Highly sensitive gas-filled detector and associated circuitry used for radiation detection and measurement. A high operating potential amplifies the primary ion pairs to allow a single radioactive particle or photon entering the chamber to be detected.

35. **RADIATION GENETIC EFFECT**: Inheritable changes, chiefly mutations, produced by the absorption of ionizing radiations. On the basis of present knowledge these effects are purely additive, and there is no threshold or recovery.

36. **GRAY (Gy)**: The SI unit of absorbed dose equal to 1 j/kg or 100 rads.

37. **HALF-LIFE, BIOLOGICAL**: The time required for the body to eliminate one-half of an administered dose of any substance by the regular processes of elimination.

38. **HALF-LIFE, EFFECTIVE**: Time required for a radioactive nuclide in a system to

be diminished 50% as a result of the combined action of radioactive decay and biological elimination. Effective half-life=(Biological half-life x Radioactive half-life) / (Biological half-life + Radioactive half-life)

39. **HALF-LIFE, RADIOACTIVE**: Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life.

40. **HALF VALUE LAYER (HALF THICKNESS)**: The thickness of any specified material necessary to reduce the intensity of an x-ray or gamma ray beam to one-half its original value.

41. **HEALTH PHYSICS**: A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

42. **INVERSE SQUARE LAW**: The intensity of radiation at any distance from a point source varies inversely as the square of the distance. For example, if the radiation exposure is 100 mRem/hr. at 1 inch from the source, the exposure will be 0.01 R/hr at 100 inches.

43. **INVESTIGATION LEVEL** (of a radioisotope): That amount of radioactive material which, if taken into the body in one event, would result in a total integrated dose of 10% of the maximum quarterly allowable dose to the whole body or critical organ.

44. **ION**: Atomic particles, atom, or chemical radical bearing an electrical charge, either negative or positive.

45. **IONIZATION**: The process by which a neutral atom or molecule acquires either a positive or a negative charge.

46. **IONIZATION CHAMBER**: An instrument designed to measure the quantity of ionizing radiation in terms of the current flow between two electrodes associated with ions produced within a defined volume. The current is directly related to type and quantity of energy penetrating the chamber. Because of chamber size limitations and low currents, ionization chambers are not usually used to measure low levels of radiation.

47. **IONIZATION, SPECIFIC**: The number of ion pairs per unit length of path of ionizing radiation in a medium, e.g. per centimeter of air or per micron of tissue.

48. **IONIZING RADIATION**: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

49. **LABELED COMPOUND**: A compound consisting, in part, of labelled molecules or atoms. By radioactivity observations the compound or its fragments may be followed through physical, chemical or biological processes.

50. **LET** (Linear Energy Transfer): Used in radiation biology and radiation effects studies to describe the linear rate of energy absorption in the absorbing medium. It is usually expressed in units of keV/micron. Generally, the higher the rate of LET of the radiation, the more effective it is in damaging the organism.

51. **MILLIROENTGEN (mR)**: A submultiple or roentgen equal to one one-thousandth (1/1000th) of a roentgen. (See Roentgen)

52. **RADIOLOGICAL MONITORING**: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

53. **AREA MONITORING**: Routine monitoring for contamination of any particular area, building, room, or equipment.

54. **PERSONNEL MONITORING**: Monitoring any part of an individual, breath, excretion, or any part of the clothing. (See Radiological Survey)

55. **NEUTRON**: Elementary particles with a mass approximately the same as that of a proton and electrically neutral. It transfers energy when it collides with an atomic nucleus.

56. **NUCLIDE**: A species of atom characterized by its mass number, atomic number, and energy state of its nucleus.

57. **OCCUPATIONAL DOSE**: The dose received by an individual in a restricted area or in the course of employment in which the assigned duties involve exposure to radiation and radioactive materials from licensed and unlicensed sources. Occupational dose does not include dose from background radiation, as a patient from medical practices, or as a member of the general public.

58. **PLANNED SPECIAL EXPOSURE**: An infrequent exposure to radiation, separate from and in addition to the annual dose. Planned Special Exposures must be approved by the NRC and the RSC.

59. **PHOTON**: A quantity of electromagnetic energy (E) whose value is the product of its frequency (f) and Planck's constant (h). The equation is: E=hf.

60. **PROTECTIVE BARRIERS**: Barriers of radiation absorbing material, such as lead, concrete, plaster, and plastic, that are used to reduce radiation exposure.

61. **PROTECTIVE BARRIERS, PRIMARY**: Barriers sufficient to attenuate the useful beam to the required degree.

62. **PROTECTIVE BARRIERS, SECONDARY**: Barriers sufficient to attenuate stray or scattered radiation to the required degree.

63. **RAD**: The absorbing dose, or amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material, equivalent to .01 J/kg. (See Gray)

64. **RADIATION 1**:The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. 2. The energy propagated through a material medium as waves; for example, energy in the form of electromagnetic waves or elastic waves. The term "radiation" or "radiant energy," when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified according to frequency as Hertzian, infrared, visible (light), ultraviolet, x-ray, and gamma ray. 3. By extension, corpuscular emissions, such as alpha and beta radiation, or rays of mixed or unknown type, as cosmic radiation.

65. **RADIOLOGICAL SURVEY**: Evaluation of the radiation hazards incident to the production, use or existence of radioactive materials or other sources of radiation

under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible change in materials or equipment.

66. **RADIOACTIVITY**: The property of certain nuclides of spontaneously emitting particles, or gamma radiation; or of emitting x-radiation following orbital electron capture or undergoing spontaneous fission.

67. **RADIONUCLIDE**: A nuclide with an unstable ratio of neutrons to protons, placing the nucleus in a state of stress. In an attempt to reorganize to a more stable state, it may undergo various types of rearrangement that involve the release of radiation.

68. **RADIOTOXICITY**: Term referring to the potential of an isotope to cause damage to living tissue by absorption of energy from the disintegration of the radioactive material introduced into the body.

69. **RELATIVE BIOLOGICAL EFFECTIVENESS (RBE)**: For a particular living organism or part of an organism, the ratio of the absorbed dose of the radiation of interest that produces a specified biological effect to the absorbed dose of a reference radiation that produces the same biological effect.

70. **REM**: The special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, distribution factor, and other necessary modifying factors. (See Sievert)

71. **ROENTGEN (R)**: The special unit of radiation exposure in air. In 1962 the International Committee on Radiation Units (ICRU) defined exposure as "the quotient dQ by dm, where dQ is the sum of all the electrical charges on all the ions of one sign produced in air when all the electrons (negatrons and positrons), liberated by photons in a volume of air whose mass is dm, are completely stopped in air". 1R = 2.58 E-4 coulombs/kg.

72. **SCINTILLATION COUNTER**: A counter in which light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photomultiplier tube.

73. **SHALLOW DOSE EQUIVALENT**: The dose equivalent for external exposure of the skin or extremities measured at a tissue depth of 0.007 cm (7 mg/cm2) averaged over an area of 1 cm2.

74. **SHIELDING MATERIAL**: Any material which is used to absorb radiation and thus effectively reduce the intensity of radiation, and in some cases eliminate it. Lead, concrete, aluminum, water, and plastic are examples of commonly used shielding material.

75. **SIEVERT (Sv)**: The SI unit of dose equivalent equal to 1 J/kg when modified by quality factors and uniformity of radiation. The Sv is expected to replace the rem.

76. **SPECIFIC ACTIVITY**: Total radioactivity of a given nuclide per unit mass or volume of a compound, element or radioactive nuclide.

77. **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 cancers are stochastic effects.

78. **THERMOLUMINESCENT DOSIMETER (TLD)**: A dosimeter made of certain crystalline materials which is capable of both storing a fraction of energy due to absorption of ionizing radiation and releasing this energy in the form of visible light when heated. The amount of light released can be used as a measure of radiation exposure to these crystals.

79. **TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE)**: The sum of the deep dose equivalent for external exposure and the committed effective dose equivalent for internal exposure.

80. **TRACER, ISOTOPIC**: The isotope or non-natural mixture of isotopes of an element which may be incorporated into a sample to make possible observation of the course of that element, alone or in combination, through a chemical, biological, or physical process. The observations may be made by measurement of radioactivity or of isotopic abundance.

81. **X-RAYS**: Penetrating electromagnetic radiation having wavelengths shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In the nuclear reactions it is customary to refer to photons originating in the nucleus as gamma rays, and those originating in the extranuclear part of the atom as x-rays.

Appendix B

General Rules for the Safe Use of Radioactive Material

1. Wear laboratory coats or other protective clothing at all times in areas where radioactive materials are used.
2. Wear disposable gloves at all times while handling radioactive materials.
3. Monitor hands, clothing and shoes for contamination after each procedure or before leaving the area. Survey the area at the end of the day.
4. Do not eat, drink, smoke, or apply cosmetics in any area where radioactive material is stored or used.
5. Wear appropriate personnel monitoring devices at all times while in areas where radioactive materials are used or stored. These devices should be worn at the working level.
6. Wear finger badges when handling one millicurie or greater 32P or other energetic beta-emitters.
7. Dispose of radioactive waste only in specially designated receptacles.
8. Never pipette by mouth.

9. Confine radioactive solutions in covered containers plainly identified and labeled with name of compound, radionuclide, date, activity, and radiation level, if applicable.
10. Always transport radioactive materials in shielding containers and always use shielding when working with radioactive materials in the lab.

Appendix C

Resource Tables

Table 1
Radionuclide Classification according to Relative Hazard Potential

Class 1

(Very High Toxicity)

90Sr + 90Y, *210Pb + 210Bi(Ra D + E), 210Po, 211At, *226Ra + 55% *daughter products,

227Ac, *228Th, *229Th, *230Th, *231Th, *233U, 238Pu, 239Pu, *241Am, 242Cm, 252Cf, plus other transuranic isotopes.

Class 2

(High Toxicity)

Ca-45, *Ca-47, *Fe-59, *Co-60, *Sr-85, Sr-89, Y-91, *Ru-106 + Rh-106, *Cd-109, *Cd-115,

*I-125, *I-131, *Ba-140 + *La-140, Ce-144 + *Pr-144, Sm-151, *Eu-152, *Eu-154, *Tm-170,

*Hg-203, *Th-232, *natural thorium, *natural uranium.

Class 3

Moderate Toxicity

*Na-22, *Na-24, 32P, 33P, 35S, Cl-36, *K-42, *Sc-46, *Sc-47, *Sc-47,

*Sc-48, *V-48, *Mn-54, *Mn-56, Fe-55, *Co-57, *Co-58, Ni-59, Ni-63, *Cu-64, *Cu-67,

*Zn-65, *Ga-67, Ga-68, *Ga-72, *As-74, *As-76, *Br-82, *Kr-85,

*Rb-84, *Rb-86, *Zr-95 + *Nb-95, *Nb-95, 99Mo*, 99Tc, *Rh-105,

Pd-103 + Rh-103, *Ag-105, *Ag-111, *Sn-113, *Te-127, *Te-129, *I-132,

*Xe-133, *Cs-137 + *Ba-137, *La-140, Pr-143, Pm-147, *Ho-166, *Lu-177,

*Ta-182, *W-181, *Re-183, Ir-190, *Ir-192, Pt-191, *Pt-193, *Au-196, *Au198, *Au-199,

Tl-200, Tl202, Tl-204, *Pb-203, *Hg-197

Class 4

Slight Toxicity

3H, 7Be, 14C, *18F, *51Cr, 68Ge 71Ge, *87mSr, *99mTc, *111In, *201Tl

1. This classification is used as part of the evaluation of an application to determine the type of laboratory or workplace standards required. The toxicity ratings are extracted from various published data but may have been shifted up or down when in the professional judgment of the health physicist local conditions indicate the need

Appendix D

Unsealed Radioactive Material Operational Workplace Standards

All operations with unsealed radioactive materials at Kent State must be conducted in such a manner and in such a workplace, as to minimize the hazard of internal ionizing radiation. The protective measures required by the KSU Radiation Safety Committee take into account the nature of the operation, the radionuclides involved, the physical and/or chemical form of the radionuclide, and the quantities that will be used. In the absence of any additional requirements set by the Radiation Safety Committee, this document establishes a set of minimum workplace standards.

1. The following guidelines establish four basic types of workplaces suitable for work involving unsealed radioactive material.
2. **Type A - Chemical Laboratory**
    A. Most low level uses of radioisotopes can be safely conducted in a normal chemical laboratory, equipped and operated as follows:
    B. The ventilation shall provide at least four air changes per hour.
    C. Work surfaces for radioactive experiments shall be smooth, impermeable, and covered with absorbent paper.
    D. Areas used for work with radioactive material must be clearly marked with radiation warning tape and used only for radioactive work.
    E. All radioactive sources shall be stored in cabinets, desiccators, or designated and labeled refrigerators and freezers.
    F. Personnel shall wear lab coats, safety glasses and gloves while working with radioactive material.
    G. All radioactive material must be secured at the end of the day (laboratory or isotopes must be locked up).
    H. Radiation survey meters are required -- as appropriate.
    I. Daily contamination monitoring by the user or worker.
    J. Contamination of hands, shoes, and clothing shall be checked at the termination of operations.

3. **Type B - Chemical Laboratory with Fume Hood**

    A. A Type B workplace is used for operations of moderate hazard that require the additional protection of an adequate fume hood.

    B. All the requirements for a Type A workplace.

    C. Operations with quantities of radioactive material exceeding the limits for a Type A workplace shall be done in a fume hood. The hood must have an average face velocity of 100 lfm (linear feet per minute) with the sash 80% (eighty per cent) open and a maximum face velocity not exceeding 125 lfm.

    D. During the time that Type B quantities are actually in use, users must make regular radiation surveys of their laboratory.

4. **Type C - Radioisotope Laboratory**

    A. A Type C workplace is required for high hazard operations. A detailed design guide for such a laboratory can be found in the American Standards Association design guide N5 2-1963. The particular details for a given laboratory must be reviewed by the Radiation Safety Committee. In general, they must include the following:

    B. All the requirements for a Type B workplace.

    C. Restricted access to and use of the area. i.e., the majority of the work involves use of radioactive material, and no desk space or other "dual" use of the area is permitted.

    D. Additional personnel protective garments may be required, such as shoe covers.

    E. Sticky paper may be required on the floor at the lab entrance.

5. **Type D – High Level Radioisotope Laboratory**

    A. A Type D laboratory is required for very high hazard operations. Detailed designs for such a laboratory must be prepared with extensive review by the Kent State University Radiation Safety Committee. Such a laboratory may require some or all of the following:

    B. Glove boxes

    C. Continuous air monitoring

    D. High efficiency filtration of exhaust air

    E. High level waste collection facilities

    F. Alarm devices to signal excessive levels of airborne radioactivity or external radiation fields

    G. Remote handling facilities

Appendix E

Radiation Surveys

1. Area Radiation Level Monitoring performed with a radiation survey meter should be sufficiently sensitive to detect 0.1 mRem/h. When monitoring an area for radiation using a survey meter the following information must be recorded:
    a. Location, date, and type of equipment used.
    b. Identification of person conducting the survey.
    c. Sketch of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.
    d. Measured exposure rates, keyed to location on sketch (highlight rates that require corrective action).
    e. Corrective action taken in the case of excessive exposure rates, reduced exposure rates after corrective action, and any appropriate comments.
2. **Contamination Levels**
    a. A series of wipe tests should be taken in all areas where activity is handled in an unsealed form. The location of the wipe tests should be indicated on the noted on the survey form and should be chosen for maximum probability of contamination.
    b. Floors, particularly adjacent to doorways, and door and drawer handles should also be wipe tested frequently. Care should be taken that cross contamination does not occur.

Appendix F

Bioassay Program

A. Bioassays will be employed to evaluate the exposure levels of individuals working with 125I, 131I, and 3H. The basic procedures to be followed are as outlined in Regulatory Guide 8.20: Applications of Bioassay for 125I and 131I (April 1978) and Regulatory Guide 8.8.32: Criteria for Establishing a Tritium Bioassay Program (July 1988).

Compliance with OAC 3701:1-38-12, Appendix C Table 1will be monitored for the occupational intake of radioactive material by and assess the committed effective dose equivalent to:

1. Adults likely to receive, in one year, an intake in excess of 10% of the applicable ALI in OAC 3701:1-38 (C) Table I and Occupational dose limits for minors shall be ten per cent of the annual occupational dose limits.
2. Dose equivalent to an embryo or fetus shall be in accordance with the following:
    a. The licensee or registrant shall ensure that the dose to an embryo or fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman does not exceed five mSv (0.5 rem). Records shall be maintained in accordance with paragraph (I) of rule 3701:1-38-20 of the Administrative Code.
    b. The licensee or registrant shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (H)(1) of this rule.
    c. The dose to an embryo or fetus shall be taken as the sum of:
        a. The dose to the embryo or fetus from radionuclides in the embryo or fetus and radionuclides in the declared pregnant woman; and (b) The dose that is most representative of the dose to the embryo or fetus from external radiation, that is, in the mother's lower torso region.
        b. If multiple measurements have not been made, assignment of the highest deep dose equivalent for the declared pregnant woman shall be the dose to the embryo or fetus, in accordance with paragraph (A)(4) of this rule; or (ii) If multiple measurements have been made, assignment of the deep dose equivalent for the declared pregnant woman from the individual monitoring device which is most representative of the dose to the embryo or fetus shall be the dose to the embryo or fetus. Assignment of the highest deep dose equivalent for the declared pregnant woman to the embryo or fetus is not required unless that dose is also the most representative deep dose equivalent for the region of the embryo or fetus.
        c. If by the time the woman declares pregnancy to the licensee or registrant, the dose to the embryo or fetus has exceeded 4.5 mSv (0.45 rem), the licensee or registrant shall be deemed to be in compliance with paragraph (A) of this rule, provided that the additional dose to the embryo or fetus does not exceed 0.5 mSv (0.05 rem) during the remainder of the pregnancy.

B. **Bioassay Program Features**

1. **125I or 131I Users:**

   a. Only materials 125I or 131I labeled materials are permitted for use. Iodination procedures with these isotopes are not permitted.

   b. Any individual who will be using unsealed volatile sources of 125I or 131I in excess of 0 .1 mCi or 1.0 mCi nonvolatile forms must notify the Radiation Safety Officer. These individuals must be monitored regularly if using greater than these amounts or if use is infrequent, must submit to a thyroid scan within 10 days of the last use. **Note**: Depending upon the nature of 125I or 131I use, it may be necessary for all individuals frequenting a laboratory where these compounds are used in excess of 1.0 mCi to be assayed as above. (Consult the Radiation Safety Committee for determination of such need.)

   c. Individuals who have activity greater than 0.12 µCi 125I or 0.04 µCi 131I will be prohibited from conducting further studies using the isotope in question until further notice from the Radiation Safety Committee.

   d. Individuals who show a positive bioassay (as described above) will be required to have repeated bioassays as determined by the Radiation Safety Committee until acceptable limits are resumed.

Any laboratory whose personnel show a positive bioassay (see III above) will be specifically monitored and its procedures will be reviewed and evaluated by the Radiation Safety Committee to determine if potential hazards exist.

2. **3H Users:**

   a. Any individual who will be using unsealed sources of 3H in excess of 50 mCi must notify the University Radiation Safety Officer and will be required to submit a urine sample 1) regularly if using 3H repeatedly or 2) within one week of the last use of greater than 50 mCi if use is infrequent. **Note**: The nature of 3H use may require that any individual frequenting the laboratory where greater than 50 mCi is used at any one time similarly submit urine samples. (Consult Radiation Safety Committee for determination of such need.)

   b. Individuals who show 3H activity greater than 5 µCi/1 will be prevented from continuing studies employing 3H and will not be allowed to resume until notified by the Radiation Safety Committee. Individuals who show a positive bioassay, and the laboratories whose personnel show a positive bioassay, will be subject to procedures as described in A.IV a. above.

   c. For those working with 32P - Ring badge dosimeters should be used to monitor doses to the hands [when individuals work with greater than 1.0 mCi quantities].

APPENDIX G

Radioactive Material Package Receipt

The person receiving the package will visually inspect it for any sign of damage (e.g. wetness, crushed). If damage is noted, stop procedure and notify Radiation Safety Officer.

2. Measure exposure rate at 1 meter from package surface and record. If greater than 10 mRem/hr, stop procedure and notify Radiation Safety Officer.

3. Measure surface exposure rate and record results on form. If greater than 200 mRem/hr, stop procedure and notify Radiation Safety Officer.

4. The RSO, Authorized User or designated laboratory Radiation Worker if activity is non-exempt.

5.Put on gloves.

6.Open the outer package (following manufacturer's directions, if supplied) and remove packing slip. Open inner package to verify contents (compare requisition, packing slip, and label on bottle), and check integrity of final source container (inspecting for breakage of seals or vials, loss of liquid, discoloration of packaging material). Check also that shipment does not exceed possession limits.

6. Wipe external surface of outer container and final source container with moistened cotton swab or filter paper held with forceps; assay and record.

7. Monitor the packing material and packages for contamination before discarding.

a. If contaminated, treat as radioactive waste.

b. If not contaminated, obliterate radiation labels before discarding in regular trash.

In all of the above procedures, take wipe tests with a paper towel, check wipes with a thin-end-window GM survey meter, and take precaution against the spread of contamination as necessary.

8. Fill out the following Radioisotope Shipment Receipt Report and send copy to the Office of Environmental Health and Safety.

Appendix H

Survey Meter Calibration Procedure and Frequency

1. Each department is responsible for keeping an inventory of survey meters and calibration due dates per State of Ohio regulations. Copies of the calibration results must be sent to the RSO.
2. Survey meters and associated probes will be sent to outside vendors that use procedures recommended by the NRC.
3. New meters will have a calibration sticker attached. All meters must be calibrated before the due date on the calibration sticker. The RSO must be notified when the meters have been sent out for calibration.

Appendix I

PRENATAL RADIATION EXPOSURE POLICY

A. **Introduction and Background**

1. Exposure of the embryo/fetus to high levels of ionizing radiation is believed to present an increased risk to the embryo/fetus. At occupational exposure levels this risk may be manifested as an increased chance of the exposed embryo/fetus developing leukemia during childhood. The State of Ohio, Bureau of Radiation Protection using the recommendations of the National Council on Radiation Protection (NCRP) and 105CMR120.218 have established the level of concern as an exposure to the embryo/fetus of greater than 500 mrem (5 mSv) during the entire gestation period. The occupational whole body equivalent exposure limit for all personnel working at KSU is 5000 mrem (50 mSv).
2. The State of Ohio requires that all employees and students who may potentially become pregnant, their supervisors and their co-workers be informed of this risk and the controls to be employed to limit the risk. The details of this information are outlined in NRC Regulatory Guide 8, 13, "Instructions Concerning Prenatal Radiation Exposure", available from the RSO.
3. All current research work at Kent State University involves exposures substantially below the State of Ohio action level for prenatal exposure. The exception would be an emergency resulting in the release of large quantities of radioactivity or grossly negligent handling of radioactive materials. While both are an extremely unlikely possibility, inform workers of the risks and their options is a prudent action.

B. **Policy Declaration**

1. The purpose of this policy is to inform employees of the known potential health risks to the embryo/fetus associated with radiation exposure and to provide pregnant employees a means to maintain their exposure below the NRC recommended prenatal dose limits, if they so choose. Kent State University will so limit occupational radiation exposure of pregnant employees who request such an accommodation during their pregnancies. However, while the State of Ohio and the University recommend that employees limit their exposure during their pregnancy, the decision to limit exposure beyond the occupational standard requirement belongs exclusively to employees. The University will implement the recommended prenatal limit when an employee submits a written request stating she wishes to be categorized as a declared pregnant worker for this particular aspect of employment.

C. **Information and Training**

1. The University will provide to all employee's information on the potential hazards of radiation exposure to the embryo/fetus. This information will include

summaries of Regulatory Guide 8.13 and a copy of this policy. An opportunity for questions and discussion will be provided and employees may be tested or questioned to determine if they understand the information and instructions. Supervisors of employees or students performing research that results in radiation exposure at other, non-Kent State University locations must inform the Radiation Safety Office of those activities.

Appendix J

Proper Segregation, Minimization and Disposal of Radioactive Wastes

Disposal of the various forms of low-level radioactive waste (radwaste) is complex, extremely difficult, and very costly. Radioactive and mixed waste (radioactive/chemical) minimization and chemical/radioactive waste segregation are critical to reducing costs, ensuring regulatory compliance, maintaining a safe workplace, and protecting the environment. All radioactive waste generators must adhere to the waste minimization and waste segregation guidelines established by the Radiation Safety Committee. Failure to adhere to the segregation and disposal procedures outlined here may result in suspension of radioactive material use privileges.

A. **SOLID RADIOACTIVE WASTE SEGREGATION AND DISPOSAL**

Solid radioactive waste generally consists of dry contaminated laboratory materials, equipment, and supplies such as paper, glass and plastic products.

1. Segregate solid radioactive waste by radionuclide(s).
2. Dispose of waste in clear plastic bags.
3. Do not leave radioactive labels and tape on short lived waste.
4. Use a separate bag per category or radionuclide grouping. Acceptable solid radioactive waste categories are noted below. Special segregation may be necessary and can be made at the discretion of the RSO or RSC.

B. **Long-Lived Radionuclide Categories [>90 day half-life]**

1. 3H and/or 14C
2. 99Tc, 22Na, 36Cl, 45Ca, 57Co, 58Co, 55Fe, 63Ni, 90Sr, 75Se, 137Cs, 65Zn

(excluding 3H and 14C)

C. **Intermediate-Lived Radionuclide Categories [>18 day - < 90 day half-life]**

1. 125I
2. 35S, 124Sb NOTE: DO NOT combine 35S with 125I.
3. 33P, 59Fe, 89Sr, 203Hg, 51Cr, 86Rb

D. **Short-Lived Radionuclide Categories [< 18 day half-life]**

a. 32P, 123I, 131I, 64Cu, 11C, 115Cd, 111Ag

b. 24Na, 99mTc, 42K

E. **IMPORTANT REMINDERS:**

1. Employ waste minimization techniques at all times.
2. DO NOT discard radioactive materials as normal trash.
3. DO NOT discard non-radioactive waste with radioactive wastes.
4. DO NOT discard vials or other containers which contain standing liquid (>0.5ml) with solid waste.
5. DO NOT discard liquid scintillation vials in with radioactive solid waste.
6. DO NOT discard lead or leaded materials in with radioactive waste.
7. DO NOT discard chemicals in with radioactive waste.
8. DO NOT discard SHARPS in with regular solid waste. Use Rad Sharps containers only.
9. DO NOT leave radioactive labels or tape on short-lived waste.
10. Maintain a record of each radionuclide, activity (uCi or mCi), and date bag filled.
11. Inform the RSO prior to disposal if contact exposure rate on container exceeds 50 mrem/hr.
12. INAPPROPRIATELY DISCARDED MATERIALS DISCOVERED IN WASTE CONTAINERS WILL RESULT IN THE CONTAINER BEING RETURNED TO THE LABORATORY OF ORIGIN FOR REPACKAGING.

D. **LIQUID RADIOACTIVE WASTE SEGREGATION AND DISPOSAL**

1. Liquid radioactive waste generally consists of rinse water from contaminated glassware and laboratory equipment, Liquid Scintillation Fluids, and other chemicals/solvents. Water soluble/dispersible non-hazardous liquid waste can be sink disposed within the limits of OAC 3701:1-38-19.
2. Sink disposal should be followed by repetitive flushing with water and can only be performed in the designated radioactive disposal sink in the laboratory. Sink disposal log sheets must be filled out for each sink discharge of radioactive material specifying the date, amount, activity, and the person responsible.

3. Organic Liquid Scintillation Counter Fluid should not to be used at Kent State University. Organic radioactive liquids generated as an inherent part of an experiment should be avoided. If generated they must be disposed of as radioactive and chemical hazardous waste. Short-lived and long-lived organic radioactive waste must be separated.
4. Short-lived radioactive organic liquid waste with half-lives of less than 65 days should be labeled and stored-for-decay in the KSU Radioactive Waste Storage Facility. After 10 half-lives the waste will be disposed of as chemical hazardous waste.
5. Long lived Organic Liquids are not permitted. There are currently no disposal outlets for this mixed waste. **Contact Radiation Safety Officer if the procedure will generate this type or waste.**

6. DO NOT mix radionuclide categories.
7. DO NOT pour organic radioactive liquids down the drain. They MUST be labeled as radioactive and chemical waste and stored in organic waste containers for treatment as specified above.
8. DO NOT mix bleach or acid with radionuclides. Bleach and acids enhance volatile nature of radionuclides.
9. DO NOT use Organic Liquid Scintillation Fluids.

E. RADIOACTIVE SHARPS

1. Sharps are those objects which represent a puncture or laceration hazard. Such objects include but are not limited to; syringe needles (capped or uncapped), razor blades, scalpel blades, xató knife blades, sharp metal objects, Pasteur pipettes, capillary pipettes, and broken glass.
2. To avoid potential injury, radioactive sharps are not to be placed in with other solid radioactive waste. All radioactive sharps must be disposed of in commercially available sharps containers labeled with radioactive material tape. These containers are to be used for sharps ONLY. Sharp objects discovered in regular radioactive waste bags will result in the bag being returned to the laboratory of origin for proper segregation and repackaging and will also result in a report of non-compliance.

F. MIXED-WASTE (RADIOACTIVE/CHEMICAL)

1. Mixed waste is defined as a mixture of low-level radioactive waste (LLRW) and a hazardous chemical.
2. A waste is considered hazardous if it is:
    a. A RCRA listed waste, and/or
    b. A characteristic waste as defined in the Code of the Federal Register (CFR), Title 40, Environmental Protection Agency (EPA), Section 261.30, Subpart D.
    c. Wastes or chemicals not listed in the RCRA list should be tested to determine if they have the properties or characteristics that render them hazardous.

    These properties include:

    a. Reactivity; release cyanide or sulfide when exposed to a pH between 2 and 12, react violently with water, generate toxic gases, vapors or fumes when mixed with water, or is capable of detonation or explosive reactions at standard temperature and pressure or when subjected to a strong initiating force,
    b. Corrosivity; pH <2 or > 12

c. Ignitability; Flashpoint < 140oF (60°C) and 4) exhibits toxicity characteristics as outlined in CFR 40, Part 261, Appendix II. To determine whether or not the LLRW generated in your laboratory is mixed waste, contact the RSO at ext.4347.

Radionuclide users are strongly encouraged NOT to generate mixed waste at Kent State University. Segregate radioactive waste from chemical waste whenever possible. DO NOT combine chemicals and radioactive waste in the same container unless the combination is an inherent part of your experimental protocols. Isolate chemical and mixed waste from all forms of pure aqueous or solid form radioactive wastes. Minimize the volume of unavoidable mixed waste at all times. Try using micro procedures if possible. The generation of mixed waste by merely mixing chemical and radioactive wastes together in the same container as a means of disposal is unacceptable and prohibited and will result in a report of non-compliance. Contact the RSO for guidance and recommendations.

Appendix K

Radiation Rules and Helpful Information

A. BETA PARTICLES

1. Beta particles of at least 70 keV energy are required to penetrate the nominal protective layer of the skin (7 mg/cm2 or 0.07 mm).
2. The average energy of a beta-ray spectrum is approximately one-third the maximum energy.
3. The range of beta particles in air is 12 ft/MeV. (Maximum range of 32P-beta is 1.71 MeV x 12 ft/MeV = 20 ft).
4. Quarter inch of Lucite will attenuate the air dose rate of 32P and other energetic beta particles by a factor of more than 200X.
5. The dose rate in Rads per hour in a solution by a beta emitter is 1.12 EC/d, where E is the average beta energy per disintegration in MeV, C is the concentration in microcuries per cubic centimeter, and d is the density of the medium in grams per cubic centimeter. The dose rate at the surface of the solution is one-half the value given by this relation. (For 32P average energy of approximately 0.7 MeV, the dose rate from 1 µCi/cm3 (in water) is 1.48 rads/hr.).
6. The surface dose rate through the nominal protective layer of the skin (7 mg/cm2) from a uniform thin deposition of 1 µCi/cm2 is about 9 rads/hour for energies above 0.6 MeV. Note that in a thin layer, the beta dose rate exceeds the gamma dose rate, for equal energies released, by about a factor of 100.
7. For a point source of beta radiation (neglecting self and air absorption) of known activity in millicuries (mCi), the dose rate (D) in rads per hour at 1 ft is given by the equation D=300 x (# Ci). This varies only slightly with beta energy. (Dose rate for 1 mCi 32P at 1 cm is approximately 300 rads/hour).

B. GAMMA RAYS

1. For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate in mR/hr. ±20% at 1 foot is: 6 x mCi x E x n, where mCi is the number of millicuries, E, the energy in MeV; and n, the number of gammas per disintegration.
2. The dose rate to tissue in rads per hour in an infinite medium uniformly contaminated by a gamma emitter is 2.12 EC/d, where C is the number of microcuries per cubic centimeter, E is the average gamma energy per disintegration in MeV, and d is the density of the medium. At the surface of a large body, the dose rate is about half this.
3. Gamma and x-ray photons up to 2 MeV will be attenuated by at least a factor of 10 by 2 inches of lead.

Appendix L

STATEMENT OF TRAINING AND EXPERIENCE

Instructions: This form is to be completed by all personnel working with radioactive materials.

NAME: _____DEPT.: _____P.I.:_____

Position Description (Circle one): Authorized User, Faculty, Staff, Grad. Student, Post Doc., Visiting Prof., Undergrad.

TYPE OF TRAINING	**WHERE TRAINED/ WHERE COURSE TAKEN**	**DATES AND DURATION OF TRAINING**	***ON THE JOB***	**FORMAL COURSE**
Principles and practices of radiation protection			Yes No	Yes No
Radioactivity measurement			Yes No	Yes No
Mathematics and calculations basic to use and measurement of radioactivity			Yes No	Yes No
Biological effects of radiation			Yes No	Yes No

RADIOISOTOPE HANDLING EXPERIENCE

ISOTOPE	**MAXIMUM AMOUNT**	**WHERE EXPERIENCE WAS GAINED**	**DATES AND DURATION OF EXPERIENCE**	***TYPE OF USE***

Have radiation exposure records been maintained for you at another institution? Yes ☐ No ☐ If "Yes", list the address below to obtain the records.

_____

_____

Social Security Number: _____ Date of Birth:_____

I have read and will abide by the University regulations as set forth in the Kent State University Radiation Safety Manual.

Signature: _____Date: _____

Use additional sheets if necessary. Attach training completion documents. Submit to the Radiation Safety Officer, lwilso51@kent.edu Fax: 330-672-3662 310A Harbourt Hall, 615 Loop Road, Kent, OH 44242

Appendix M

Radiation Safety Report
Receipt of Radioactive Materials

P.O #_____ Isotope_____

Date Ordered_____ Activity (mCi)_____

Date Received_____ Investigator_____

Shipping Label

White I ____
Yellow II ____
Yellow III ____

Other ____
None ____

Package Condition

Good_____
Other_____
(Describe Below)

Shipper_____ Carrier_____

Package Wipe Check

Surface Monitored	G/M Shielded (mR/hr.)	Filter Wipe (dpm)
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Inspected by: _____ Date_____

Appendix N

KENT STATE UNIVERSITY

Radioactive Materials Inventory and Wipe Test Result Form

Radioactive Materials Inventory and Wipe Test Results (Month /Year)	
Principal Investigator	
Completed by	Department
Building	Room #

Radioactive Materials used during the month
Select from the dropdown box

Inventory: Report all values in Millicuries (0.010 mCi instead of 10 µCi)

Activity	^{14}C	^{3}H	^{125}I	^{22}Na	^{32}P	^{33}P
Liquid Waste						
Solid Waste						

RADIOACTIVE WIPE TEST REPORT: WIPE TESTS MUST BE REPORTED AS DPM NOT CPM

ATTACH A DRAWING OF ROOM AND LABEL WIPE LOCATIONS

Date	Survey or Wipe	Location	MR/H for Survey or DPM for Wipe	Isotope	Initials	Comments

Attach drawing of room indicting wipe locations.

Appendix O

APPLICATION FOR USE OF RADIOACTIVE MATERIALS

Submit application to
Radiation Safety Officer, lwilso51@kent.edu Fax: 330-672-3662
310A Harbourt Hall, 615 Loop Road, Kent, OH 44242

a. Name and Title:_____
(Principal Investigator)

2. Building and room number:_____

3. Department:_____ Phone ext._____

4. Duration of Use: ☐ Permanent ☐ Temporary (6 months or less)

5. Nature of Program: ☐ Research ☐ Instruction

6. List the names of all persons using radioactive materials under supervision of the applicant. Submit a Form RSP-2, Training and Experience, for each person.

7. List all open sources of radioactive material needed:

RADIOISOTOPE	**MATERIAL FORM** organic, inorganic, liquid, solid.	**ACTIVITY** per procedure, mCi	**POSSESSION LIMIT** Max. no. mCi of each that you will possess at any time

8. List sealed radioactive sources needed:

RADIOISOTOPE	**MANUFACTURER / MODEL NUMBER**	**SERIAL NO.** (if known)	**ACTIVITY** (mCi)

9. RADIATION DETECTION EQUIPMENT:

   a. List the type of portable survey meter you now have or will buy. Make certain that your equipment is able to detect the energy and type of radioisotopes being used.

Type of Instrument (Make and Model No.)	**Sensitivity Range** (mR/hr. or CPM)	**Type of use** Radiation or Contamination Monitoring

   b. Personnel dosimetry needed. Complete and submit an RSP-3 form for each person needing dosimetry.

10. **PROPOSED USE**: Give sufficient detail of your proposed use and radiological controls (i.e., security of isotopes and waste, restricted and unrestricted areas, etc.) in your laboratory setup that will be used to keep personnel exposures As Low As Reasonably Achievable (ALARA). (Use a separate sheet if necessary).

11. Describe your laboratory. Attach a diagram of the lab and include: type of floor, bench top material, type of hood, show location of equipment coming into contact with radioactive materials and distinguish restricted areas from unrestricted areas if the entire lab is not restricted. Indicate routine wipe test locations.

12. The Kent State University is required by the State of Ohio to have an ALARA program which tries to keep personnel exposures **A**s **L**ow **A**s Reasonably **A**chievable. Please describe shielding, remote handling equipment and personnel monitoring procedures if gamma or high energy beta emitters are to be used.

13. Describe your proposed procedures for disposal of radioactive waste. Ensure the physical separation of long- and short-lived radioactive waste containers.

14. Occupancy area - list type of personnel and number in the area who are <u>not radiation workers</u> and will occupy the lab. Notify the Radiation Safety Officer of any change in occupancy.

NAME	UNDERGRADUATE	GRADUATE	FACULTY/STAFF

APPLICATION AGREEMENT

I have read and I will abide by the University regulations as set forth in the Radiation Safety Manual. I agree to notify the Radiation Safety Officer at least one month before I close down my laboratory to transfer and/or dispose of all my radioactive material and waste and clean any contamination to background levels.

The Radiation Safety Program requires a close out survey to ensure that no contamination exists prior to releasing the laboratory for occupation by other department personnel. If it is necessary to conduct further decontamination, we understand it will be the department's responsibility to cover any costs incurred.

_____

Signature of Authorized User Date

_____

Signature of Department Chairperson Date

Appendix P

REQUEST FOR PERSONNEL DOSIMETERS

Instructions: Each applicant must complete this form and submit it to the Radiation Safety Officer, 310A Harbourt Hall, Fax 2-23662. If you are a new user, you must submit a Statement of Training form, RSP-2.

1. NAME: _____SEX: _____
   (First) (MI) (Last) M/F
2. Social Security No.: _____ Date of Birth: _____
3. Authorized User: _____Dept._____
4. Will you work with radiation sources longer than 6 months? _____
5. Date badge service first needed: _____
6. Type of radiation to which applicant may be exposed (X-ray, beta, gamma, neutron):

   List isotopes, x-ray equipment, etc.:

7. Building and room number where badge will be located: _____
8. Have you been monitored for occupational exposure to radiation prior to coming to Kent State University? _____

   If yes, please fill out the attached Request for Radiation Exposure History for each institution at which radiation exposure was monitored. Photocopy additional sheets as necessary

****

For Radiation Safety Program Use Only

Department: _____ Frequency: _____

Badge Type: Body: _____ Ring: _____

Date service started:_____ Date service ended: _____

REQUEST FOR RADIATION EXPOSURE HISTORY

Date: _____
Institution: _____

Address: _____

_____

Department: _____

Dates Employed: From: _____To: _____

Attention RSO:

Please furnish the occupational exposure history of the individual named below, who may have received radiation exposure at your institution, so that we may complete our records to be in compliance with the U. S. Nuclear Regulatory Commission regulations.

Name of Employee: _____
SSN#: _____

I hereby authorize Kent State University to secure my past exposure history.

Signature: _____ Date: _____

Thank you for your prompt attention to this matter. Please send the information requested to:

LaKetta Wilson, RSO
310A Harbourt Hall,
615 Loop Road, Kent, Oh 44242
lwilso51@kent.edu
Fax: 330-672-3662

Sincerely,

LaKetta Wilson
Radiation Safety Officer