

Radiation Safety Manual

Kent State University

Radiation Safety Manual

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I. PREFACE

- A. The goal of the Kent State University radiation safety program is to protect users, co-workers and the general public from exposure to radiation and radioactive materials. The operating philosophy of Kent State University, the Division of Research and Graduate Studies, and the Academic Departments is to maintain all radiation exposures ALARA (as Low as Reasonably Achievable). Use of ionizing radiation sources on the campus is in accordance with State and Federal regulatory requirements. Copies of Kent State University's radioactive materials license and pertinent State and Federal regulations are on file in the Radiation Safety Office and are available for reading to those interested.
- B. The objective of this manual is to provide the user of ionizing radiation sources with a ready reference to regulatory agency requirements, Kent State University organizational lines, responsibilities and operating procedures relevant to the use of radioactive materials, and the maintenance of the ALARA concept. Several appendices are included to explain terms used in radiation protection and to describe radioisotope workplace and decontamination standards.
- C. Copies of the Kent State University Radiation Safety Manual (RSM) are available through the Division of Research and Graduate Studies and on line. Revisions are posted to the web and the PI's are notified of the changes.

II. ORGANIZATION AND AUTHORITY

A. **Government Regulations and Standards**

- 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. In 1999 the State of Ohio became an agreement state with the Nuclear Regulatory Commission and assumed all authority for implementation, inspection, and enforcement of regulations and licensing for the possession and use of radioactive materials.
- 3. In accordance with the guides and regulations referred to above, academic institutions are required, as a condition of license, to operate a radiation safety program. Kent State University's license application and a description of its radiation safety program are available from the following sources:
 - a. Radiation Safety Officer (RSO), Division of Research and Graduate Studies.

B. **Administration of the Radiation Safety Program**

- 1. Radiation Safety Committee. Under the terms of the academic institution license, the government guides and regulations applicable to the use, possession, handling or transportation of radioisotopes on campus are enforced by the Radiation Safety Committee. The Committee will meet at least once per semester to review operations regarding radioisotopes at Kent State University, and will report its activities and findings to the Vice President for Research and Dean of Graduate Studies
 - a. Committee Membership. The Radiation Safety Committee consists of current users of radioisotopes and the Radiation Safety Officer (Chairman).
 - b. Committee Authorities. The Radiation Safety Committee will have the authority to:
 - (1) Establish, approve and/or review overall safety procedures and those for individual users.
 - (2) Review and investigate cases of infringement of guidelines and procedures.
 - (3) Recommend to the Vice Provost and Dean to suspend authorization for use of radioisotopes and ionizing radiation.
 - (4) The Radiation Safety Committee and its members will be available to users as sources of advisement, and for procedures involving radiation safety.
- 2. Radiation Safety Officer (RSO).

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- a. The Radiation Safety Officer is appointed by the Vice President for Research and Dean of Graduate Studies
 - b. The Radiation Safety Officer can recommend suspension of any operations involving radioactive materials where hazards or violations exist. Operations may resume only after review and approval by the Radiation Safety Committee.
 - c. Duties
 - (1) Coordinate or supervise: periodic safety evaluations and tests; provision of bioassays; establishment of systems and procedures for receipt, distribution, storage and disposal of radioactive materials; establishment of internal record-keeping systems and procedures as required by law, such as personnel dosimetry reports.
 - (2) Offer a training course at least once per year or give information reminding the Housekeeping, Campus Police, and other support personnel of proper precautions.
 - (3) Ensure incoming radioactive materials packages are inspected and checked for leaks.
 - (4) Periodically (not less than twice per year) conduct Wipe Checks of all labs using radioactive materials.
 - (5) Periodically inspect laboratory working conditions.
 - (6) Approve purchase requests for radioactive materials to ensure license possession limits will not be exceeded
 - (7) Coordinate disposal of radioactive materials.
 - (8) Maintain inventory of radioactive materials on campus and update monthly.
 - (9) Maintain records of: Personal Occupational Exposures, Radioactive Materials Receipts, Disposal of Radioactive materials, User Wipe Tests, Periodic Wipe Checks and Laboratory Monitoring.
 - (10) Coordinate calibration of survey meters.
 - (11) Coordinate leak testing of sealed sources.
 - (12) Coordinate the education and training of new users.
 - (13) Conduct final inspection of portions of labs being returned to normal use. This is not to be interpreted as ceasing to conduct experiments using radioactive materials or the decommissioning of a site, building or outdoor area as listed in 3701:1-40-18 but a return of the partial area of a laboratory that was being used for radioactive materials use to normal use.
3. Departmental Radiation Safety Officers
- a. Each Department using radioactive materials will appoint a Departmental Radiation Safety Officer (DRSO) with the following duties:
 - (1) Attend the Radiation Safety Committee meetings.
 - (2) If RSO is unavailable due to illness or vacation, the backup RSO is not available the Departmental RSO may be called upon to inspect, wipe test and accept radioactive material packages that may arrive do to unforeseen circumstances that have already been approved for purchase by the RSO and inventoried.
 - (3) Support the Radiation Safety Program's ALARA goal by providing guidance to Department Licensees, Users and RSO
 - (4) Conduct leak testing of sealed sources used by the Department.
 - (5) Ensure meters are calibrated annually.
4. Faculty Licensees.
- a. Requirements:
 - (1) Authorization for holding and using radioisotopes is given to designated individuals, known as Faculty Licensees (referred to as PI or user), who must be full-time faculty members , who will be held responsible for the safe and proper use, storage and disposal of all radioisotopes under their jurisdiction. (Those working with radioactive

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- materials under the supervision of a Faculty Licensee or PI are referred to as radiation workers or workers.)
- (2) Faculty Licensees must be listed on the University Radioactive Materials License.
 - (3) To be included on the license, the faculty member must complete the Training and Experience Form, Appendix M. This provides a summary of past training and experience in handling radioactive materials. The completed form will be submitted to the RSC for review and approval.
- b. Duties:
- (1) Responsible for the health and safety of persons entering their laboratories.
 - (2) Abide by decisions made by the Radiation Safety Officer, the Radiation Safety Committee, the Vice Provost and Dean regarding corrective procedures.
 - (3) Ensure that the individuals working in the laboratories have completed the necessary training programs before beginning to handle radioactive materials.
 - (4) Ensure that all personnel involved in research protocols are included in the personnel monitoring program if necessary.
 - (5) Monitor their laboratories ambient condition as often as necessary to determine that exposure to radiation is maintained ALARA.
 - (6) Post rooms and materials with proper warning signs.
 - (7) Properly disposal of radioactive wastes and prevent the accumulation of excessive quantities of waste material in the laboratory.
 - (8) Notifying the RSO of any significant changes in techniques or physical facilities
 - (9) When necessary, faculty members may request the Chair of the Radiation Safety Committee to schedule an agenda item in their behalf.
5. Radiation Workers.
- a. UNDERGRADUATE, GRADUATE, AND POST-DOCTORAL STUDENTS AS WELL VISITING FACULTY must meet specific requirements before beginning to work with radioactive materials.
 - b. All must attend or have attended a Radiation Safety Class and pass a written examination. The examination will test the individuals 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.
 - c. All must work under the supervision of one of the faculty members named in the license. All will be responsible for setting up and completing their experiments in as safe a manner as possible. They shall report all unsafe conditions to the faculty member responsible for that area or the Radiation Safety Officer.
 - d. Individuals who are listed on another NRC license as individuals who may use and supervise the use of licensed material (e.g. visiting faculty) must supply documentation of previous training and experience.
 - e. Past coursework or experience gained on the job will not exempt a student from completing the above requirements. Students, (e.g. medical students, undergraduates, etc.) not conducting their own research projects, but performing tasks in a technical manner under the direct supervision of a faculty member will be expected to meet the requirements of "Technical Support Staff" rather than of "Radiation Workers".
 - f. All must attend an annual refresher training consisting of lecture or viewing of Radiation Safety Tapes.
6. Technical Support Staff
- a. All technical staff in laboratories where radioactive materials are handled will work under the supervision of a faculty member named in the license. They will

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- have adequate knowledge of radiation safety procedures through previous experience, direct training by their supervisor, and/or watching the video tapes on working with radioactive chemicals available from the Radiation Safety Office.
- b. Technicians shall be responsible for completing their assigned tasks in as safe a manner as possible. Whenever questions arise regarding the safety of a procedure, they must ask the faculty member under whom they work or the RSO to correct any potentially unsafe procedures.
7. Ancillary Personnel.
- a. All ancillary personnel (e.g. security, cleaning, maintenance, etc.) who enter laboratories containing radioactive materials will be briefed either by memo or by group meetings at least once a year by the RSO.

III. Radiation Exposure Control and Monitoring.

A. Definition of Areas:

1. Unrestricted areas are areas in which a person continually present receives less than 2 mRem in any 1 hour. (Halls, Offices, Non-Radiation Labs.) Control measures for exposure from external radiation are not required.
2. Radiation areas are areas where radioactive materials are used or stored that could result in a dose above those cited as maximum allowable for unrestricted areas.
 - a. All rooms in which radioactive materials or radiation producing equipment are used must be specifically approved for that purpose. Approval for use will be given by the Dean for Research and Sponsored Programs with the advice of the Radiation Safety Committee and the Radiation Safety Officer. They will consider the isotope to be used, the maximum activity expected, the volatility and dispensability of the radioactive material, and the specific procedures to be carried out in the area. Other factors which may influence a decision are the amount of bench space, fume hoods, bio hoods, shielding, storage space, and waste handling facilities.
 - b. 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. Radiation levels in Radiation Areas may not exceed 2 mRem/hour.
 - c. Radiation Areas are in Cunningham Hall (Department of Biological Sciences), the Science Research Laboratory (Liquid Crystal Institute, Biology, Chemistry and Physics), Smith Hall (Department of Physics), and Williams Hall (Department of Chemistry).
3. Restricted Radiation Areas.
 - a. An area where radiation levels may exceed 2 mRem/hr.
 - b. Responsibility of a Restricted Radiation Area is assigned to an Authorized User and the Radiation Safety Officer.
 - c. Access to the room is obtained by borrowing the key from the Authorized user. The key must be returned by the end of that working day, and cannot be kept for evening or weekend use of the area. The Authorized user is responsible for monitoring the condition of the area. If any unsafe condition is found, the most recent user of the room will be notified and held responsible for returning the room to a safe contamination-free condition.
4. Before Beginning an Experiment in an Approved Area.
 - a. Before working in a Radiation Area or a Restricted Radiation Area, all personnel must have successfully completed the training program and arranged for personnel radiation exposure monitoring including bioassay if necessary. The Faculty Licensee supervising the research project is responsible for the health and safety of personnel on the project. They must be certain that all

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requirements and preparations have been met before assigning someone to work with any radioactive materials or radiation producing equipment. All personnel must also know how to contact the Radiation Safety Officer in the event of an emergency, and be familiar with the emergency procedures outlined in Section 3.8.

- b. Before attempting any new procedures with radioactive materials, it is suggested that a "dry run" be carried out to help anticipate possible hazards during the experiment. An aid in detecting potential flaws is to perform the experiment with a fluorescent material or dye. Ultra-violet light can then be used to survey the area following an experiment to help indicate where materials have contaminated the area.

B. Posting of Signs and Labels.

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."
2. The area within laboratories in which radioactive materials are used will be delineated and labeled with a sign contain the radiation symbol and the words "CAUTION RADIATION AREA." For sealed sources: if the level 12 inches from the source container surface is not in excess of 5 millirem/hour, a sign is not required.
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.
 - a. 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. Emergency Procedures and phone numbers of the RSO and principal investigator will be posted in all radioisotope use areas.

C. Personnel Film Badge Program.

1. KSU contracts with Tech/Ops Landauer, Inc. or other suitable firms, for a monthly radiation film badge program. The standard badge given to personnel is a "whole body" badge. Special ring or wrist badges are available for situations in which hand 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.
2. Who Should Wear a Film Badge?
 - a. All individuals handling gamma ray and high energy beta emitting isotopes (e.g., 125-I, 131-I, 32-P) must wear a film badge. Although OAC 3701:1-38-14 (B) only requires workers to wear film badges if their exposure exceeds 10% of the allowable year dose, all workers in areas where these isotopes are handled should also wear film badges, and those using x-ray producing equipment are strongly advised to wear them. Individuals working exclusively with low energy beta emitters (e.g., 3-H, 14-C) need not wear a badge since these radiations are not of sufficient energy to expose the film.
3. Exposure Limits
 - a. No individual over 18 years of age will receive in one year, from any radiation source, an occupational dose in excess of the following:

Whole body; head and trunk; active blood-forming organs: 5,000 mrem (50 Sv)
(Total Effective Dose Equivalent)
Lens of eye: 15,000 mrem (150 Sv)
Skin of whole body and extremities: 50,000 mrem (500 Sv).
 - b. Higher exposures must meet special government regulations and be performed under the direct supervision of the Radiation Safety Officer. Call the RSO for information on Planned Special Exposures.
 - c. Persons under 18 years of age are limited to maximum exposures of 1/10th of

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the above levels.

- d. Declared pregnant woman per OAC 3710:1-38-01 are limited to a maximum exposure of 500 mrem/9 month gestation period.
- e. Exposure to the general public (non-occupational) is limited to maximum levels of 100 mrem/year.

D. **Bioassay Program**

1. The Bioassay will be performed following guidelines published by the U.S. NRC on individuals who handle large quantities of tritium (3-H) labeled compounds and/or large quantities of 125-1 or 131-1 labeled compounds. See Appendix F for summary of requirements.
2. Bioassays are performed on an "as needed" basis, and are only required under certain circumstances.
3. Kent State University's policy is to minimize as much as possible those situations requiring bioassays.

E. **Laboratory Monitoring Program**

1. Monitoring of laboratories will be accomplished by the use of survey meter and surface wipe tests.
2. Every investigator, technician, student, or other individual is responsible for monitoring his/her own operations. Many projects are of such a nature that monitoring instruments must be on hand at all times. The Radiation Safety Office has a limited supply of survey meters which can be borrowed for short periods of time.
3. Each principal investigator who under the terms of our State of Ohio Materials License is authorized to use and to supervise the use of radioactive materials, will monitor all rooms under his or her supervision in which radioactive isotopes are used or stored.
4. Radiation levels will be monitored using a survey meter during operations using isotopes.
5. Surface wipe test will be conducted at least once during the month when radioactive materials are used and results reported to the RSO.
6. Wipes are performed to detect removable surface contamination. Special attention should be paid to bench surfaces and edges, hood aprons and window handles, refrigerator door handles, cabinet handles, door knobs, and floor areas around work areas and near the doors leading out of the room. Areas wiped with filter paper should be approximately 100 square centimeters. The radioactivity on the filter paper should be evaluated with a liquid scintillation counter using a three-window program.
7. Surface wipes must be taken in all areas where radioactive materials are used, except where they are only used as sealed sources.

F. **Surface Decontamination.**

1. If wipe tests indicate levels of contamination above 200 dpm, the affected areas must be decontaminated and/or the sources of the radiation must be better shielded.
2. If bodily contamination has occurred, the procedures outlined in Section H.4. (Emergency Procedures) must be followed.
3. If the contamination is estimated to be greater than 1 uCi the procedures outlined in Section H.2. must be followed.
4. If the contamination is estimated to be not greater than 1 uCi, the affected area must be washed with a strong detergent (e.g., Isoclean or Radwash) and rinsed with warm water, the wash and rinse water can be disposed of in the drain. The surface must be rubbed dry with paper towels, and these towels must be discarded as radioactive waste.
5. 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.

G. **Monthly Reports.**

1. The principal investigators shall submit for all rooms under their supervision a monthly written report of the monitoring results to the Radiation Safety Officer on the Radioactive

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Contamination Report form, Appendix O. These reports must show date performed, instrument used, result in mR/h (for surveys) or disintegrations per minute (dpm) (for wipes), location, person performing the monitoring, and any corrective action taken. These reports will be kept on file by the Radiation Safety Officer.

H. **Checks by Radiation Safety Officer.**

1. The Radiation Safety Officer or his designee will survey the laboratories at least twice per year to ascertain that proper procedures are followed and contamination is maintained at acceptable levels.
2. Reports of these surveys, showing date performed, instrument used, result in mR/h (for surveys) or dpm (for wipes), location, person performing the monitoring, and any corrective action taken, will be kept on file by the Radiation Safety Officer.

I. **Leak Tests of Sealed Sources**

1. Each sealed source acquired from another person and containing licensed material other than ³H, with a half-life greater than 30 days, and in any form other than gas, shall be tested for contamination and/or leakage before use. Subsequently, each such source shall be tested at least once every 6 months, unless it contains only 100 microcuries or less of beta and/or gamma emitting materials or only 10 microcuries or less of alpha emitting material.
2. Currently, the sealed sources covered by our materials license and requiring periodic leak tests are:
 - a. ²³⁹Plutonium encapsulated as a Pu-Be neutron source (AEC #N320B90; original activity: 2 Ci) located in Smith Hall, room 203E.
3. Wipe tests of the sources listed above, will be done under the direct supervision of the Physics Department Radiation Safety Officer, Dr. Bryon D. Anderson
4. Wipe tests will be done using commercially available kits with analysis performed by independent laboratories.
5. Wipe tests will be done with filter paper. After use, the filter paper will be put immediately in the container supplied for this purpose, and the container will be marked with proper identification.
6. The reports of the wipe tests will be kept by the persons in charge of the units tested, and a copy of each report will be submitted to the RSO to be kept on file.

IV. **ROUTINE OPERATING PROCEDURES**

A. **Purchasing Radioactive Materials**

1. All purchase requisitions for radioactive materials must be signed by the Radiation Safety Officer or his designate, 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.

B. **Receiving Radioactive Materials**

1. Only materials that have been properly ordered through the Radiation Safety Office will be received. All materials not ordered through the Radiation Safety Office will be returned to the sender unopened. When a package of radioactive material arrives on campus, the receiving personnel will inspect the package per Appendix G for signs of damage (i.e., crushed box or wet areas due to leaks) before accepting it from the carrier. If the package is damaged to the degree that radioactive material may have contaminated its surface, the receiving personnel must contact the Radiation Safety Office immediately. The Radiation Safety Officer will inspect the package, the receiving area, the carrier's vehicle, and all personnel who handled the package, to determine the extent of possible contamination. The carrier will not be released from campus until it is determined that

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neither be nor his vehicle is contaminated.

2. If the package is received in good condition, the receiving personnel will sign for its receipt and notify the Radiation Safety Officer of its arrival. Within three hours of notification, the Radiation Safety Officer, backup Radiation Safety Officer or Departmental Radiation Safety Officer will monitor the package with a survey meter and/or surface wipes, and complete a "Receipt of Radioactive Materials" form, Appendix N. Wipes, if preformed, will be done on the surfaces of the packages of non-exempt quantities down to the inner container by the RSO or Authorized User.. The receipt form, the packing slip, and the copy of the original requisition will be kept on file by the RSO. The amount received will be entered on the inventory maintained by the Radiation Safety Officer.
3. The material will be delivered to the Authorized User's Laboratory.

C. Storage

1. All radioactive materials must be stored in an area of controlled access to prevent unauthorized removal and/or use of the material. Normally, the material will be stored in a laboratory or container that can be locked when personnel authorized to handle the material are not present. If any radioactive materials are to be stored in an uncontrolled area such as a hallway refrigerator or freezer, the container must be capable of being locked to assure that no unauthorized removal can occur.
2. The licensee is responsible for seeing that all storage containers, vials, columns, glassware, or any other items containing radioactive material are marked with an approved label bearing the words "Radioactive Material", Containers or materials used in common facilities must also bear the user's name and lab number.

D. Use

1. All radioactive materials must be handled in designated Radiation Areas or Restricted Radiation Areas. Radioactive material should be treated as hazardous substances and handled with all cautionary procedures normally accorded such substances. Normal precautions should include the following safety measures:
 - a. No eating, drinking, smoking, applying cosmetics, or any other procedure that could lead to inadvertent ingestion of radioactive materials is permitted in Radiation Areas.
 - b. Pipetting radioactive materials by mouth is prohibited
 - c. Food or drink, even in sealed containers, must not be stored in the same refrigerator or cold room where radioactive materials are used.
 - d. Film badges must be worn if using isotopes or equipment that emit gamma ray, x-ray, or high-energy beta emissions.
 - e. Clothing should be disposable in the event of a major spill. Lab coats and disposable gloves should be worn when handling radioactive materials. Care must be taken not to contaminate other surfaces when working with gloves. Traces of radioactive material are sometimes inadvertently transferred to refrigerator handles, telephones, sink faucets, centrifuge doors and rotors, and instrument dials by handling them with a "hot" glove. Be sure to monitor such surfaces following use to assure that no contamination has taken place.
 - f. Glassware, tongs, pipettes, and other similar tools used in a radiation area should be suitably marked and not used in a non-radiation area. "Hot" glassware should be disposed of or washed promptly.
 - g. Work should be confined to as small an area as possible. This simplifies the problem of confinement and shielding, and aids in limiting the affected area in case of an accidental contamination.
 - h. All work involving the likelihood of aerosol production must be done in hoods, glove boxes or similar protective devices.
 - i. Cover work surfaces with an absorbent paper with waterproof backing or confine the handling of materials to an impervious tray. Change paper and wash trays frequently to prevent the spread of radioactive contamination.

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- j. Monitor the area with a sufficiently sensitive survey meter before, during, and after an experiment to detect contamination spots and to maintain radiation exposure levels within allowable limits.
- k. Minimize the duration of exposure to high activities of gamma and high- energy beta-emitting radioisotopes. Confine large quantities of such isotopes to a lead storage box or lead pig in a remote spot of the laboratory (c.g., back corner of a hood or refrigerator). Use long handled forceps or tongs if possible to reduce exposures.

E. **Inventory**

- 1. The Radiation Safety Officer is responsible for maintaining inventory records of all radioactive materials on the KSU campus, and ensuring that the possession limit for each specific isotope is not exceeded. Investigators licensed to conduct research involving radioactive materials are responsible for maintaining up-to-date records of the receipt, disposal (both by drum and by drain, and decay of radioactive materials under their supervision.
- 2. At the end of each calendar month, the Radiation Safety Officer will notify each licensee to submit a Radioactive Inventory and Wipe Test Results form for the current month. The Radiation Safety Officer tracks the activity of any isotopes received through the office during that month (see Receiving), and calculates the activity of each isotope lost by decay. (Note that the duration of a month is taken as 30.438 days, the average number of days per month).
- 3. Each licensee is to complete the sections on amounts placed into waste and amounts placed down the drain for release into the sanitary sewer system and return the form to the RSO within 7 working days. All entries are to be made in millicuries carried to three decimal places.
- 4. Materials transferred from one investigator to another are to be noted as a minus quantity in the receipt column of the donating investigator's form, with a notation as to whom the material was transferred to. The investigator receiving the material must note it in the receipt column and note from whom it was received.
- 5. **ALL TRANSACTIONS ARE TO BE REPORTED AS OF THE LAST CALENDAR DAY OF THE MONTH.**
- 6. On receipt of the signed personal inventory forms, the Radiation Safety Office enters the disposal data from each investigator in its inventory, and prepares for each isotope a summary of month inventory and use form. The Radiation Safety Officer will ascertain that these forms correspond with the data submitted by the licensees and with the file on Materials Received, and check them for computational accuracy. He will compare the total activity present on campus (both in laboratories and in waste drums) with the possession limit for each specific isotope. If the total present on campus exceeds 90% of the possession limit, he will notify all licensees. In such an event, the Radiation Safety Officer may consider requesting an amendment from the State of Ohio to increase possession limits, or disposing of stored waste of the isotope.

F. **Transportation of Radioactive Materials Off-Campus**

- 1. Limited quantities of radioactive materials may be transported off-campus to another facility licensed by the State to receive the radioactive material. Due to the numerous State, NRC and DOT regulations governing transportation of these materials on public highways, **ALL TRANSPORTATION OFF-CAMPUS MUST PROCEED THROUGH THE RADIATION SAFETY OFFICE.** Transfers will only be arranged from the Radiation Safety Office of Kent State University to the Radiation Safety Office of the other institution.

G. **Radioactive Material Waste Storage and Disposal Error! Bookmark not defined.**

- 1. Radioactive wastes must be stored only in restricted areas approved by the Radiation Safety Officer. Presently all waste is stored on campus. See the Kent State University Proper Segregation/Minimization & Disposal of Radioactive Wastes (Appendix K) for

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more details.

2. Liquid Wastes:

- a. Liquid wastes may be sink-disposed within the limits of OAC 3701:1-38-12 © Table III, provided the wastes are readily soluble or dispersible in water. In general sink disposal should be followed by flushing for 5 minutes with water. A single sink in each laboratory is designated for the disposal of radioactive wastes. Logs must be kept of disposal operations specifying the date, amount, activity, and the person responsible.
- b. Inorganic, biodegradable, water soluble liquid scintillation cocktails (LSF) may be disposed of down the designated sink as long as they meet the criteria referenced in 1 above.
 - (1) There are three different categories of liquid scintillation vials, as far as disposal requirements are concerned:
 - (a) Deregulated vials with non-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 not appearing to be hazardous wastes.
 - (b) 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.
 - (c) Radioactive vials: vials containing more than 0.05 uCi/gram of 3-H or 14-C, and vials containing other radioisotopes.
 - (2) Vials in the first category may be emptied in the sink, rinsed, and disposed of as regular trash. Vials in the other two categories must be disposed of in separate drums. It is the responsibility of each principal investigator to make sure that his or her vials are disposed of properly.
- c. Organic liquid scintillation cocktails should not 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 liquid wastes must be separated.
- d. Liquid waste containing isotopes of Phosphorous and Iodine are to be stored-for-decay in the KSU Radioactive Waste Storage Facility. After 10 half lives the waste will be disposed of as chemical hazardous waste.
- e. Long lived Organic Liquids should be avoided at all costs. There is currently no disposal outlet for this type of waste. Treat to separate radioactivity either by filtration through carbon or ion exchange. Combine untreatable waste with an adsorbent solid material, such as vermiculite, and separate from all other radioactive solid waste. Label as long-lived radioactive/hazardous waste.

3. Solid Wastes

- a. Wastes should be screened by the user so that only those necessary to dispose of as radioactive wastes are included in the radioactive solid wastes.
- b. Whenever possible, isotopes with relatively short half-lives, such as ^{32}P , ^{35}S , ^{125}I , etc., should be allowed to decay in storage for a period of at least 10 half-lives and then disposed of with normal trash after verifying that the radiation level is at background. For β and γ -emitters average surface contamination levels should be at background with removable levels at background. ONLY the RSO can dispose of decay-in-storage waste.
- c. The term "radioactive waste" includes any and all wastes that contain, or are contaminated with, any radioactive material used in the laboratory. This includes liquids, solids, trash, animal carcasses and excreta, used scintillation counting liquids, etc. Waste and trash which are not radioactive should never be mixed with radioactive waste as the cost to KSU for disposing of radioactive waste is very high. All wastes must be classified and disposed of accordingly.
- d. Needles, scalpels, and any other sharp objects must be packaged separately.

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- e. Animal carcasses containing radioactive material in excess of 0.05 uCi of 3-H or 14-C per gram must be placed in polyethylene bags and frozen until disposed of. Large animals such as dogs or monkeys should be cut up to facilitate placement of the carcass in a drum. Final disposal will be via our broker. (Our current broker is ADCO Services, Inc. Their current packing instructions specify that animal carcasses must be packaged in a special double-walled container; this is generally a 30 gallon drum inside of a 55 gallon drum, but larger or smaller containers are also available.)
 - f. Waste containing biological, pathogenic, or infectious material (syringes, test tubes, capillary tubes, etc.) must be autoclaved prior to packaging to render it nonpathogenic
4. Short Half-Life Isotopes.
- a. Short half-life isotopes (those with a physical half-life of less than 65 days) are to be separated from long half-life isotopes, for each category listed above. Long half-life wastes are shipped for disposal; short half-life wastes are decayed on site

H. EMERGENCY PROCEDURES

1. We are all human and occasionally make mistakes. There is no shame in reporting spills or contamination. There is considerable NOT REPORTING an accident involving radioactive materials. On the recommendation of the Radiation Safety Committee, the VP & Dean for Research and Sponsored Programs may remove the privilege to handle radioactive materials from persons failing to report promptly any emergencies involving radioactive materials.
2. Low-Level Spills
 - a. A low-level spill is one that is confined to a limited area and does not increase the radiation levels in the area beyond the acceptable limits of 2 mR/hr.
 - b. The spill is confined to absorbent paper or an impervious tray.
 - c. Radiation levels 1 meter from the center of the spill do not exceed 2 mR/hr.
 - d. The total quantity of material spilled is greater than 1 uCi but less than 1 mCi.
 - e. The licensed principal investigator supervising the activities in the laboratory where the spill occurred must be notified immediately. The investigator is responsible for assuring that the spilled material is collected and disposed of properly. Decontamination procedures should include the following steps:
 - (1) If the spill was absorbed by bench paper, collect the paper and place it into a plastic bag. Label the bag and place it into the appropriate radioactive waste drum.
 - (2) If the spill was confined to an impervious tray, wash the tray with decontamination solution. The rinse water may be disposed of in the sink if levels of radiation are within permissible limits (see Disposal). Otherwise, it must be disposed of as radioactive liquid waste and placed into the appropriate container.
 - (3) Clean the surrounding area with decontamination solution.
 - (4) Following decontamination procedures the area should be monitored with a survey meter and surface wipes. If contamination persists decontamination procedures must be repeated until detectable radiation levels are as low as reasonably achievable (ALARA).
 - (5) The principal investigator is responsible for submitting a Radioactive Contamination Report to the Radiation Safety Officer within 7 days. The report will be retained in the Radiation Safety Office.
 - (6) Remember:
 - (a) NOTIFY: Notify persons in the area that a spill has occurred.
 - (b) PREVENT THE SPREAD: Cover the spill with absorbent paper.
 - (c) MARK OFF THE AREA: Do not allow anyone to leave the area without being monitored.

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- (d) NOTIFY THE RADIATION SAFETY OFFICE.
- (e) 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.
- (f) SURVEY: With a low-range, thin-window G-M survey meter, check the area around the spill, hands, and clothing for contamination

3. Major Hazard Spill

a. A major hazardous spill is any spill that is more significant than a low-level spill. A spill is a major hazardous spill if it meets any of the following criteria:

- (1) The quantity spilled is greater than 1 mCi.
- (2) The quantity spilled is greater than 1 uCi and is not confined to absorbent paper or an impervious tray.
- (3) Radiation levels 1 meter from the center of the spill exceed 2 mR/hr.
- (4) **THE RADIATION SAFETY OFFICER MUST BE NOTIFIED IMMEDIATELY WHEN A MAJOR HAZARDOUS SPILL OCCURS.**
- (5) The Radiation Safety Officer and the Department RSO will determine the extent of the spill by survey meter and 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 principal investigator may enter the area until the decontamination procedures are completed.
- (6) The Radiation Safety Office is responsible for directing the decontamination and assuring that the area is as free of contamination as reasonably achievable when decontamination procedures are completed. The principal investigator is responsible for promptly executing the decontamination procedures deemed necessary by the Radiation Safety Officer.
- (7) The Radiation Safety Officer and the principal investigator will complete a Radioactive Contamination Report. A meeting of the Radiation Safety Committee will be convened to determine corrective measures to prevent, if possible, future hazardous spills of a similar nature.
- (8) Reports to the State of Ohio will be made per OAC 3701-1-38-21 by the RSO.
- (9) Remember:
 - (a) CLEAR THE AREA: Notify all persons not involved in the spill to vacate the room
 - (b) 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.
 - (c) SHIELD THE SOURCE: If possible, the spill should be shielded, but only if it can be done without further contamination or without significantly increasing your radiation exposure.
 - (d) CLOSE THE ROOM: Leave the room and lock the door(s) to prevent entry.
 - (e) CALL FOR HELP: Immediately notify the Radiation Safety Officer.
 - (f) PERSONNEL CONTAMINATION: Contaminated clothing should be removed and stored for further evaluation by the

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Radiation Safety Officer. If the spill is on the skin, flush thoroughly and then wash with mild soap and lukewarm water.

4. External Bodily Contamination
 - a. Radioactive materials in contact with body surfaces (e.g., hands) should be removed promptly using approved decontamination products such as D-Con or Radwash. The area should be scrubbed gently and rinsed with lukewarm water.
 - b. DO NOT USE HARD OR CAUSTIC SOAPS.
 - c. DO NOT SCRUB THE AREA WITH AN ABRASIVE TOOL (e.g., SCRUB BRUSH).
 - d. AVOID PROCEDURES THAT MAY BREAK THE SKIN CAUSING POTENTIAL TRANSFER OF MATERIAL INTERNALLY.
 - e. The Radiation Safety Officer should be notified if the material in contact with the skin:
 - (1) Exceeds 10,000 dpm.
 - (2) Is in a chemical form that may readily be absorbed.
 - (3) Gives a dose greater than 500 mR
 - (4) If any of these conditions exist, the Radiation Safety Officer will determine whether decontamination can proceed on site or in the Emergency Room facilities of Robinson Memorial Hospital (Ravenna, Ohio).
 - f. If decontamination is carried out on site under the direction of the Radiation Safety Officer, he will perform a urinalysis bioassay to determine whether the individual can be considered decontaminated. The Radiation Safety Officer will complete the Radioactive Contamination Report.
5. Internal Bodily Contamination
 - a. Ingestion or injection of radioactive materials must be reported to the Radiation Safety Officer or his staff immediately. They will transfer the individual as a patient to the Emergency Room facilities of Robinson Memorial Hospital (Ravenna, Ohio).
6. The maximum limits suggested for fixed contamination on hands, body surfaces, personnel clothing and shoes are:
 - a. Alpha activity - 200 dpm /100 cm²
 - b. Beta-gamma activity - 0.2 mrad/hr at 2 cm.

I. **Returning Laboratories and Equipment to Normal Use.**

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 β and γ -emitters average surface contamination levels should be below 5,000 dpm/ 100 cm² with removable levels less than 1,000 dpm/ 100 cm².
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.

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v. RADIOISOTOPE USE

A. Application Procedures and Authorization for Use of Radioisotopes

1. No person may use, or bring into an official part of KSU, radioisotopes in any amount without notification of the Radiation Safety Officer, or the departmental representative in the case of quantities not requiring a specific license and sold to the general public, or without approval of the Radiation Safety Committee in the case of quantities which do not require a specific license.
2. Authorization for holding and using radioisotopes is given to designated individuals, known as Principal Investigators (referred to as PI or user), who must be full-time faculty members, who will be held responsible for the safe and proper use, storage and disposal of all radioisotopes under their jurisdiction. (Those working with radiation under the supervision of a PI are referred to as radiation workers or workers.)
3. Applications for the initial use, or modification of existing authorizations, of radioisotopes must be submitted in written proposal form to the Radiation Safety Officer who may approve the use on an interim basis (App. P). The RSO will forward the proposal with comments and recommendations to the Radiation Safety Committee for review and approval at the next RSC meeting. Permits to use radioisotopes are granted to undergraduates, graduates, and post doctorates working under the direct supervision of an authorized PI. Written proposals for Authorization and Permits should include such information as:
 - a. Names of Principal Investigators who will supervise individual laboratory/program safety procedures;
 - b. Specific isotopes and maximum quantities involved;
 - c. Chemical and/or physical form;
 - d. Purpose and nature of proposed use, with citation of specific operations that may effect contamination and/or exposure (e.g., grinding, evaporations, etc.);
 - e. Training and experience of supervisory and other persons handling materials (App. Q);
 - f. Training provided technicians, graduate students, etc. (See App. Q);
 - g. Monitoring instrumentation available on site, or available for use if not on site (location);
 - h. Storage and disposal methods specific to type of material or individual academic departments;
 - i. Safety procedures and equipment;
 - j. Other information as may be required by government regulations or recommended by the RSO or the RSC.
4. The Principal Investigator is responsible for providing written guidelines and analytical procedures for handling specific isotopes used. Copies are to be given to individual users and submitted with the application.
5. Proposals will be distributed to each member of the Radiation Safety Committee for review and comment. Except where vetoed or modified by the Committee, the recommendations made on each proposal by the Radiation Safety Officer will determine the authorization and conditions of use of radioisotopes by individual users.

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 Principal Investigators 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.

APPENDICES

Appendix A. Glossary of Terms {tc "Appendix A. Glossary of Terms " \l 2}

ABBREVIATIONS: RSC - Radiation Safety Committee; RSO - Radiation Safety Officer; RSM - Radiation Safety Manual.

ABSORPTION: The phenomenon by which radiation imparts some or all of its energy to any material through which it passes.

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 practicable consistent with the purpose for which the licensed activity undertaken.

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.

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.

ANNIHILATION (Electron): An interaction between a positive and negative electron; their energy, including rest energy, being converted into electromagnetic radiation (annihilation radiation).

ATOM: Smallest particle of an element which is capable of entering into a chemical reaction.

AUTORADIOGRAPH: Record of radiation from radioactive material in an object, made by placing the object in close proximity to a photographic emulsion.

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.

BEQUEREL (Bq): The SI unit of activity in disintegrations per second (s⁻¹). (1 Ci=3.7E10 Bq).

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.

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.

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

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

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.

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.

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.

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).

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

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).

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

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

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

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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.

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 (62.4×10^6 MeV/g or the gray (1 J/kg).

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)

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.

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

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.

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 electron volts.

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.

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.

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

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.

GENETIC EFFECT OF RADIATION: 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.

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

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.

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. $\text{Effective half-life} = (\text{Biological half-life} \times \text{Radioactive half-life}) / (\text{Biological half-life} + \text{Radioactive half-life})$

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

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.

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.

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.

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.

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

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

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.

IONIZATION, SPECIFIC: The number of ion pairs per unit length of path of ionizing radiation in a medium, e.g.

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per centimeter of air or per micron of tissue.

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

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.

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.

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

MONITORING, RADIOLOGICAL: 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.

Area Monitoring: Routine monitoring for contamination of any particular area, building, room, or equipment.

Personnel Monitoring: Monitoring any part of an individual, breath, excretion, or any part of the clothing. (See Radiological Survey)

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.

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

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.

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.

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

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

Protective Barriers, Primary: Barriers sufficient to attenuate the useful beam to the required degree.

Protective Barriers, Secondary: Barriers sufficient to attenuate stray or scattered radiation to the required degree.

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)

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.

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.

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.

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.

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.

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.

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)

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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". $1R = 2.58 \text{ E-4 coulombs/kg}$.

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

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.

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.

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.

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

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.

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.

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

TRACER, ISOTOPIC: The isotope or nonnatural 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.

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 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 labelled 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. Useful Tables

Table 1. Classification of Radionuclides 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.

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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, *Au-198, *Au-199, Tl-200, Tl-202, 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 judgement of the health physicist local conditions indicate the need.

Appendix D. Workplace Standards for Operations with Unsealed Radioactive Material

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.

I. The following guidelines establish four basic types of workplaces suitable for work involving unsealed radioactive material.

a. Type A - Chemical Laboratory

Most low level uses of radioisotopes can be safely conducted in a normal chemical laboratory, equipped and operated as follows:

- 1) The ventilation shall provide at least four air changes per hour.
- 2) Work surfaces for radioactive experiments shall be smooth, impermeable, and covered with absorbent paper.
- 3) Areas used for work with radioactive material must be clearly marked with radiation warning tape and used only for radioactive work.
- 4) All radioactive sources shall be stored in cabinets, desiccators, or designated and labeled refrigerators and freezers.
- 5) Personnel shall wear labcoats, safety glasses and gloves while working with radioactive material.
- 6) All radioactive material must be secured at the end of the day (laboratory or isotopes must be locked up).
- 7) Radiation survey meters are required -- as appropriate.
- 8) Daily contamination monitoring by the user or worker.
- 9) Contamination of hands, shoes, and clothing shall be checked at the termination of operations.

b. Type B - Chemical Laboratory with Fume Hood

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

- 1) All the requirements for a Type A workplace.
- 2) 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.

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

c. Type C - Radioisotope Laboratory

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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:

- 1) All the requirements for a Type B workplace.
- 2) 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.
- 3) Additional personnel protective garments may be required, such as shoe covers.
- 4) Sticky paper may be required on the floor at exit from the lab.

d. Type D - High Level Radioisotope Laboratory

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:

- 1) Glove boxes.
- 2) Continuous air monitoring.
- 3) High efficiency filtration of exhaust air.
- 4) High level waste collection facilities.
- 5) Alarm devices to signal excessive levels of airborne radioactivity or external radiation fields.
- 6) Remote handling facilities.

Appendix E. Radiation Surveys

1. Radiation Levels Monitor area with a radiation survey meter sufficiently sensitive to detect 0.1 mRem/h. Record:
 - 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 series of wipe tests should be taken in all areas where activity is handled in unsealed form. The location of wipe tests should be indicated on the above mentioned survey form and should be chosen for maximum probability of contamination.

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

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(C) Table 1 will 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

(2) Occupational dose limits for minors shall be ten per cent of the annual occupational dose limits specified for adult workers in paragraph (A) of OAC 3701:1-38.

(H) Dose equivalent to an embryo or fetus shall be in accordance with the following:

(1) 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.

(2) 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.

(3) 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

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(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.

(i) 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.

(4) 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.

The major features of the bioassay programs are as follows:

A. For users of 125I or 131I:

I. Only materials already labeled with 125I or 131I are to be used. Procedures to carry out iodinations with these isotopes are not to be performed.

II. 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.)

III. Individuals who show activity greater than 0.12 μ Ci 125I or 0.04 μ Ci 131I will be prohibited from conducting further studies employing the isotope in question until further notified by the Radiation Safety Committee.

IV. a. Individuals who show a positive bioassay (see III 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.

B. For users of 3H:

I. 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.)

III. Individuals who show 3H activity greater than 5 μ Ci/l 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. Procedures & Form for Safely Opening Packages Containing Radioactive Material

1. 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

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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. In Vivo Labeling Studies Procedures

1. In vivo labeling experiments are to be conducted only by individuals whose protocols have been approved by both the University Committee on the Care and Use of Animals (UACC), to ensure adherence to guidelines for the humane treatment of animals during the course of the experiments, and the University Radiation Safety Committee (RSC) to ensure proper isotope handling and monitoring.
2. All such studies are to be conducted in facilities which are designed for this purpose and approved by the RSC.
3. All cages and other materials for use in these in vivo labeling studies will be kept in the designated room and its environs and shall be used exclusively for such studies, i.e. these cages and other materials will not be used for routine animal housing, maintenance, or experimentation.
4. At the conclusion of the in vivo labeling experiment (irrespective of duration) the following procedures must be followed:
 - a. All bedding materials must be suitably disposed of as radioactive solid waste;
 - b. All cages and areas used in the study must be thoroughly cleaned by the investigator;
 - c. All such cages and areas must be monitored carefully to ascertain that they are free of any detectable radioactive contaminants;
 - d. All carcasses must be disposed of per Section G.3.e.
5. The direct responsibility for overseeing and manipulating the organisms carrying radioisotopes (and the cages and other materials) during the in vivo experiments rests with the investigator. No individual who has not been specifically approved by the RSC for direct use of radioisotopes will be involved with the animals or materials used in any in vivo labeling experiment.

Radioactive Nucleic Acids and Derivatives

Experiments involving the use of radioactive nucleic acid and radioactive nucleic acid derivatives present a special hazard in that some of these compounds have been incorporated. The following procedures have been adopted by the Radiation Safety Committee for the use by all workers involved with such material.

1. Special care should be used during all experiments which involve the use of radioactive nucleic acids, radioactive nucleic acid derivatives, or substances in which these compounds have been incorporated.
2. When the quantity of a radioactive isotope used in any one experiment is less than 200 μCi , the following precautions suffice:
 - a. The experiment should be done only in a designated area within the laboratory. This area should be physically separated from other work areas if at all possible. The bench top should always be covered with absorbent paper.
 - b. Rubber or plastic gloves and lab coats should be worn at all times during the handling of the radioactive materials.
3. When the quantity of a radioactive isotope used in any one experiment exceeds 200 μCi , experimental manipulations must be carried out in a fume hood. Radiation Safety should be consulted concerning the adequacy of fume hoods used for this purpose (Appendix D).

Application to Use Radioactive Materials in Animals

Principal Investigator Dept. Ext.:

Personnel Assigned to the Project Ext.:

Brief Description of the Project

Identity of Radioactive Material:

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Source: Storage Location:

Administration of Material per Animal: Preparation: Dose:

Frequency: Total Dose: Method of Administration:

Animals Proposed for Project:

Species Strain Quantity Proposed Date:

Amount of Biohazardous Material, Radionuclide or Toxic Metabolite Secreted/Excreted after Dosing: a) Urine c) Expired Air

b) Feces d) Time Frame

e) Skin application and length of activity after application

Protocol Number

1. What is the specific method of chemical neutralization and/or decontamination for this material?

Reference

2. If there is no known method of decontamination, will double washing of equipment and incineration of waste materials be sufficient safety precautions to meet the needs of this project? Yes No

3. What protective garments are necessary for personnel assigned to this project to ensure maximum safety? (It is the responsibility of the investigator to provide these.)

All projects involving the use of any biohazardous materials or radioactive substances must be performed in accordance with UACC safety protocols for these substances.

Signature of the Principle Investigator Date:

FOR UACC USE ONLY

Date Received: Animal Care Personnel

Space Assigned: Associated with Project

Approval:

Animal Care Supervisor Radiation Safety Officer

Appendix I. Calibration of Survey Meters Procedures & Frequency

Each Department is responsible for keeping an inventory of Survey Meters and calibration due dates per State of Ohio regulations. Copies of calibration results are to be sent to the RSO.

Survey meters and associated probes will be sent to outside vendors that use procedures recommended by the NRC.

New meters purchased by laboratories will usually arrive on campus with a calibration due date sticker attached.

When these meters reach their due dates, it is the responsibility of the researchers to notify the RSO that it has been sent out for calibration.

Appendix J. PRENATAL RADIATION EXPOSURE POLICY

Introduction and Background

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).

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.

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.

Policy Declaration

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

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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.

Information and Training

The University will provide to all employees 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 K. 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 work place, 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:

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.

- Segregate solid radioactive waste by radionuclide(s).
- Dispose of waste in clear plastic bags. Do not leave radioactive labels and tape on short lived waste.
- 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.

A. 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)

B. 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

C. Short-Lived Radionuclide Categories [<18 day half-life]:

1. 32P, 123I, 131I, 64Cu, 11C, 115Cd, 111Ag
2. 24Na, 99mTc, 42K

IMPORTANT REMINDERS:

- Employ waste minimization techniques at all times.
- DO NOT discard radioactive materials as normal trash.
- DO NOT discard non-radioactive waste with radioactive wastes.
- DO NOT discard vials or other containers which contain standing liquid (>0.5 ml) with solid waste.
- DO NOT discard liquid scintillation vials in with radioactive solid waste.
- DO NOT discard lead or leaded materials in with radioactive waste.
- DO NOT discard chemicals in with radioactive waste.
- DO NOT discard SHARPS in with regular solid waste. Use Rad Sharps containers only.
- DO NOT leave radioactive labels or tape on short-lived waste.
- Maintain a record of each radionuclide, activity (μ Ci or mCi), and date bag filled.
- Inform the RSO prior to disposal if contact exposure rate on container exceeds 50 mrem/hr.

INAPPROPRIATELY DISCARDED MATERIALS DISCOVERED IN WASTE CONTAINERS WILL RESULT IN THE CONTAINER BEING RETURNED TO THE LABORATORY OF ORIGIN FOR REPACKAGING.

LIQUID RADIOACTIVE WASTE SEGREGATION AND DISPOSAL

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.

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Sink disposal should be followed by repetitive flushings 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.

Organic LSF should not 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.

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.

Long lived Organic Liquids should be avoided at all costs. There are currently no disposal outlets for this mixed waste. Treat to separate radioactivity by carbon filtration or ion exchange. Filters and ion exchange media will then be treated as mixed waste while the organic eluent will be treated as chemical hazardous waste. Monitor activity to ensure that levels are at background. Combine untreatable waste with adsorbent material and separate from all other waste categories. Label as "Mixed" Waste, Radioactive and Chemical Hazardous Waste.

- DO NOT mix radionuclide categories.
- 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.
- DO NOT mix bleach or acid with radionuclides. Bleach and acids enhance volatile nature of radionuclides.
- DO NOT use Organic Liquid Scintillation Fluids. Switch to the inorganic, biodegradable fluids.

RADIOACTIVE SHARPS

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, xacto knife blades, sharp metal objects, pastuer pipettes, capillary pipettes, and broken glass.

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.

MIXED-WASTE (RADIOACTIVE/CHEMICAL)

Mixed waste is defined as a mixture of low-level radioactive waste (LLRW) and a hazardous chemical. Specifically, a waste is considered hazardous if it is: 1) a RCRA listed waste, and/or 2) a characteristic waste as defined in the Code of the Federal Register (CFR), Title 40, Environmental Protection Agency (EPA), Section 261.30, Subpart D. 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 1) 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, 2) Corrosivity; pH <2 or > 12, 3) Ignitability; Flashpoint < 140oF (60oC) and 4) exhibits toxicity characteristics as outlined in CFR 40, Part 261, Appendix II. In order to determine whether or not the LLRW generated in your laboratory is mixed waste, contact the RSO at ext.4996.

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 L. Radiation Rules of Thumb and Helpful Information

BETA PARTICLES

- a. 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).
- b. The average energy of a beta-ray spectrum is approximately one-third the maximum energy.
- c. 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).
- d. 1/4 inch of lucite will attenuate the air dose rate of 32P and other energetic beta particles by a factor of more than 200X.

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- e. 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 ^{32}P average energy of approximately 0.7 MeV, the dose rate from $1 \mu\text{Ci}/\text{cm}^3$ (in water) is 1.48 rads/hr).
- f. The surface dose rate through the nominal protective layer of the skin ($7 \text{ mg}/\text{cm}^2$) from a uniform thin deposition of $1 \mu\text{Ci}/\text{cm}^2$ 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.
- g. 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 $D=300 \times (\# \text{ Ci})$. This varies only slightly with beta energy. (Dose rate for 1 mCi ^{32}P at 1 cm is approximately 300 rads/hour).

GAMMA RAYS

- a. For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate in mR/hr $\pm 20\%$ at 1 foot is: $6 \times \text{mCi} \times E \times n$, where mCi is the number of millicuries, E , the energy in MeV; and n , the number of gammas per disintegration.
- b. 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.
- c. Gamma and x-ray photons up to 2 MeV will be attenuated by at least a factor of 10 by 2 inches of lead.

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Appendix M. STATEMENT OF TRAINING AND EXPERIENCE { TC “Appendix M.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): Principle Investigator, Faculty, Staff, Grad. Student, Post Doc., Visiting Prof., Undergrad.

<i>TYPE OF TRAINING</i>	<i>WHERE TRAINED/ WHERE COURSE TAKEN</i>	<i>DATES AND DURATION OF TRAINING</i>	<i>ON THE JOB</i>	<i>FORMAL COURSE</i>
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

<i>ISOTOPE</i>	<i>MAXIMUM AMOUNT</i>	<i>WHERE EXPERIENCE WAS GAINED</i>	<i>DATES AND DURATION OF EXPERIENCE</i>	<i>TYPE OF USE</i>

Have radiation exposure records been maintained for you at another institution? Yes ___ No ___. If “Yes”, indicate the address where these records may be obtained and the dates these records cover.

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:** _____

If additional space is needed, use the back of this sheet. Attach certificates or other documents certifying successful completion of training. Return original to the Radiation Safety Officer, 191 MACC Annex, Kent State University,

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Kent, Oh 44242; FAX 2-2658

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Appendix N
Radiation Safety Report
Receipt of Radioactive Materials{ TC “Appendix N
Radiation Safety Report
Receipt of Radioactive Materials” }

P.O # _____ Isotope _____
Date Ordered _____ Activity (mCi) _____
Date Received _____ Investigator _____

Shipping Label

Package Condition

White I _____
Yellow II _____
Yellow III _____

Other _____
None _____

Good _____
Other _____
(Describe Below)

Shipper _____ Carrier _____

Agreement Between P.O. and Packing Slip:

	Purchase order	Packing Slip	Agree (Y?N?)
Isotope	_____	_____	_____
Activity (mCi)	_____	_____	_____
Chemical Form	_____	_____	_____

Package Wipe Check

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

Inspected by: _____ Date _____

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P.I. Signature: _____

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7. List sealed radioactive sources needed:

RADIOISOTOPE	MANUFACTURER AND MODEL NUMBER	SERIAL NO. (if known)	ACTIVITY in mCi

8. 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.

9. 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).

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10. 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.

11. The Kent State University is required by the State of Ohio to have an ALARA program which tries to keep personnel exposures As Low As Reasonably Achievable. Please describe shielding, remote handling equipment and personnel monitoring procedures if gamma or high energy beta emitters are to be used.

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

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

NAME	UNDERGRADUATE	GRADUATE	FACULTY/STAFF

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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 is 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 Principal Investigator

Date

Signature of Department Chairperson

Date

Radiation Safety Manual

Appendix Q REQUEST FOR PERSONNEL DOSIMETERS{TC “Appendix Q Request For Personnel Dosimeters” }

Instructions: Each applicant must complete this form and submit it to the Radiation Safety Officer, 191 MACC Annex, Fax 2-2658. If you are a new user, submit a Statement of Training form, RSP-2.

- 1. NAME: _____ SEX: _____
(First) (MI) (Last) M/F
- 2. Social Security No.: _____ Date of Birth: _____
- 3. Principal Investigator: _____ 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: _____

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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:

Radiation Safety Officer
Research and Graduate Studies
191 MACC Annex
Kent State University
Kent, Oh 44242

Sincerely,

Thomas S. Bialke
Radiation Safety Officer