BOSTON COLLEGE

RADIATION SAFETY MANUAL

Boston College
Office of Environmental Health and Safety
Carney Hall 4th Flr.
140 Commonwealth Ave.
Chestnut Hill, MA 02467

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PREFACE

The goal of the Boston College Radiation Safety Program is to protect users, co-workers and the general public from exposure to radiation and radioactive materials. The operating philosophy of the Boston College Administration, the Environmental Health and Safety (EHS) Office and the academic departments is to maintain all radiation exposures As Low As Reasonably Achievable (ALARA). Use of ionizing radiation sources on the campus is in accordance with State and Federal regulatory requirements. Copies of Boston College's radioactive materials license and pertinent State and Federal regulations are on file in the EHS Office and are available for review to those interested.

The objective of this manual is to provide the user of ionizing radiation sources with a ready reference to regulatory agency requirements, Boston College organizational roles and 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, to assist in radiation exposure and shielding calculations, and to describe radioisotope workplace and decontamination standards.

Copies of the Boston College Radiation Safety Manual (RSM) are available through the Office of Environmental Health and Safety[1], the offices of academic departments where ionizing radiation is used, and at the following link EHS Radiation Safety. Revisions of the manual are made available to these department offices and to principle investigators in those laboratories where ionizing radiation is used. Previous editions of this manual are to be discarded.

I. ORGANIZATION AND AUTHORITY

A. Government Regulations and Standards

1. The use of radioactive byproduct materials (yielded in or made radioactive through nuclear reactions involving plutonium, Uranium-233, or Uranium-235 reactants) is governed by licenses issued by the Massachusetts Department of Public Health, Radiation Control Program.
2. Except as otherwise specifically provided, Commonwealth of Massachusetts Department of Public Health (MADPH) regulation 105 CMR 120.000 applies to all persons who receive, possess, use, transfer, own, or acquire any source of radiation, provided, however, that nothing in 105 CMR 120.000 shall apply to any person to the extent such person is subject to regulation by the U.S. Nuclear Regulatory Commission (NRC). Regulation by the Commonwealth of Massachusetts of source material, byproduct material, and special nuclear material in quantities not sufficient to form a critical mass is subject to the provisions of the agreement between the State and the NRC and to 10 CFR Part 150 of the NRC's regulations.

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[1] Office of Environmental Health and Safety
Carney Hall – 4th flr.
Contact: Eric Johnson, Senior EHS Officer - RSO
eric.johnson.5@bc.edu

Copies of these regulations may be examined at Carney Hall, in the Boston College, EHS Office or at NRC Regulation 10 CFR Part 150.

3. All persons using, possessing, receiving, or in any way handling materials, instruments or machines which emit ionizing radiation in the Commonwealth of Massachusetts are also subject to rules and regulations issued by the Massachusetts Department of Public Health, except as may be specifically exempted. Copies of these regulations are available from:

   Massachusetts Department of Public Health
   Radiation Control Program
   Schrafft Center, Suite IM2A
   529 Main Street
   Charlestown, Massachusetts 02129
   617-242-3035
   Email: RadiationControl@massmail.state.ma.us
   http://www.mass.gov/dph/rcp

   Copies may also be examined at the Environmental Health and Safety Office or at Mass DPH Radiation Control regulation 105 CMR 120.000.

4. Users of radioactive materials at Boston College are collectively governed by the license granted by the Massachusetts Department of Public Health, Radiation Control Program to Boston College. The current Boston College license number is 00-6427. In March of 1997 the Commonwealth of Massachusetts 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.

5. 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. Boston College's license application and a description of its Radiation Safety Program are available from the Office of Environmental Health and Safety.

B. Administration of the Radiation Safety Program

Under the terms of the academic institution license, the Boston College Radiation Safety Committee enforces all government guides and regulations applicable to the use, possession, handling or transportation of radioisotopes on campus by University staff and students. The Committee will meet quarterly to review operations regarding radioisotopes at Boston College, and will report its activities and findings to the Radiation Safety Officer (RSO).

1. Committee Membership

The Radiation Safety Committee consists of representatives from all University units where radioisotopes are used, the RSO (ex officio), an academic administrator, a representative of the Office of Research Administration, the Radiation Safety Technician (non-voting), and the Director of Environmental Health and Safety (ex officio), and faculty representation from departments that use radioisotopes.

2. Committee Authorities

The Radiation Safety Committee will have the authority to:

a. Establish, approve and/or review general safety procedures and any additional ones for individual users.
b. Approve new proposals for radioisotope users and uses *prior to purchase or acquisition of radioisotope materials*
c. Review and investigate cases of infringement of guidelines and procedures.
d. Suspend authorization for use of radioisotopes and ionizing radiation.
e. Conduct an annual review of the radiation safety program: The RSC shall conduct or initiate and review an audit of an annual review of the total Boston College radiation safety program. The purpose of the review will be to examine the program to determine the level of compliance, and to detect areas in which modification of established procedures may be desirable.
f. Conduct or authorize a semi-annual inspection of sites that use radioisotopes
g. As needed, the Environmental Health and Safety (EHS) Office will offer a training course for Housekeeping, Campus Police, and other support personnel. This course will include basic information about radiation from radioactive substances and their hazards; rules and regulations concerning the use of radioactive substances; management of accidents and spills; and emergency procedures.
h. The RSC and its members will be available to users as sources of information regarding the regulations and procedures involving the safe use of radiation.
i. The RSC will appoint the Radiation Safety Officer (RSO), who must be confirmed by the MA DPH Radiation Control Program.

3. Committee Meetings

RSC meetings are held quarterly and minutes are available through the EHS Office.

4. Radiation Safety Officer (RSO)

a. The Radiation Safety Officer will report on the status of radiation safety to the University official responsible for overall University compliance with Federal and State safety regulations (Tom Chiles – Vice Provost for Research & Academic planning).
b. The Radiation Safety Officer will be an *ex officio* member of the Radiation Safety Committee except that he/she may also serve on the Committee as a departmental representative.
c. 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.
d. The Radiation Safety Officer will coordinate or supervise:
    1. Periodic safety evaluations and tests;
    2. Provision of bioassays to users as necessary;

3. Establishment of systems and procedures for receipt, distribution, storage and disposal of radioactive materials;
4. Establishment of internal record-keeping systems and procedures as required by law, such as personnel dosimetry reports.

e. The RSO may approve radioisotope user applications on an interim basis pending review by the Radiation Safety Committee.

f. Records of personnel who have undergone training and the nature of the training will be maintained under the supervision of the RSO in the Environmental Health and Safety Office.

The RSO may delegate any or all of the above authorities to the Associate Radiation Safety Officer (ARSO).

5. Radiation Safety Technician (RST) *(Boston College has contracted with a licensed Radiation Consultant to provide Radiation Safety Technicians and other support services)*

The RST will:

a. Inspect and perform leak tests on all packages when received, according to the requirements of the Commonwealth of Massachusetts and the Nuclear Regulatory Commission (NRC). The campus-wide radioisotope inventory is immediately updated to avoid exceeding holding limits.

b. Perform monthly inspections of all labs where radioisotopes are used and immediately rectify any situation not in compliance with Massachusetts and NRC regulations (including supervising clean up and re-inspection). The RST is responsible for maintaining permanent records of inspections and isotope inventory to assure all holdings are within allowed limits. These records will be submitted to the RSO monthly for review and long-term storage.

c. Collect and survey solid waste generated in laboratories for commercial radiation waste pick up, prepare barrels and paperwork, as well as assist driver in waste shipments.

d. Instruct users on proper disposal of liquid waste.

e. Assist in coordinating calibration of survey meters.

e. Perform quarterly leak testing and record results for standard and sealed sources

f. Know the contents of the Boston College Radiation Safety Manual and work with the RSO to make certain that all users have been properly trained and correctly managing radioisotopes in the labs.

g. Supervise clean up and inspection in the event of spills, file written reports (per request of the RSO)

h. Inspect equipment being moved from a radioactive area; perform termination inspections of labs being closed.

i. Survey x-ray devices on campus annually.

k. Assist Radiation Safety Officer with administrative duties including data collection and reporting.

II. RADIATION EXPOSURE: CONTROL AND PERSONNEL LIMITS

A. Definition of Areas

Federal and State regulations provide the following definitions of areas:

1. Unrestricted areas are areas in which a person continually present receives less than 2 millirem (mrem) in any one hour, or 100 mrem in any 7 consecutive days *to any portion of the body*. Control measures for exposure from external radiation are not required.
2. Restricted areas are areas where radiation levels are above those cited as maximum allowable for unrestricted areas. Access to restricted areas must be controlled by the individual users of radioisotopes employed in the areas by controlling the following: a) only those currently trained in Radiation Safety should be allowed access; b) appropriate shielding and Personal Protective Equipment are available and used.

B. Personnel Monitoring and Exposure Limits

1. Personnel monitoring devices are required by law, and records must be kept, if any individual receives, or is liable to receive, a dose in any calendar year in excess of 10% (1% for persons under 18) of the values listed below. Dosimeters are to be worn by all users of radiation at the mCi level [for detectable energy emitting radionuclides]. Badges are issued only after certification by the RSO and are available through the department or the EHS Office. Dosimetry records are available through the RSO. Badges are exchanged on a quarterly basis in the departments. Yearly exposure history records will be available at the EHS Office by March 1 for the previous year.
2. No individual 18 years of age or over 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)

   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.

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

3. Pregnant women; are limited to a maximum exposure of 500 mrem/9 month gestation period.
4. Exposure to the general public (non-occupational) is limited to maximum levels of 100 mrem/year.
5. Only materials already labeled at the manufacturer with Iodine-125 (I^{125})or Iodine-131 (I^{131})are to be used. Procedures to carry out iodinations with these isotopes are not to be performed at Boston College.

C. Laboratory Monitoring

The Radiation Safety Technician (RST) will perform routine surveys of laboratories actively using radioisotopes on a monthly basis. Records of these surveys are to be maintained by the RSO at the Environmental Health and Safety Office.

D. Airborne Contamination Limits

Airborne radioactivity concentration limits to prevent overexposure of any organ as a result of breathing contaminated air are summarized for common radioisotopes (concentrations are in µCi) in Table 1 of Appendix C and Table I Column 3 of 105CMR120.296. These limits are 10% of the NRC's Annual Limits on Intake (ALIs) above which airborne and internal monitoring are required. If you feel that you are potentially being exposed to concentrations above these limits, notify the RSO immediately.

E. Posting of Signs and Labels

Government regulations specify the following signs and conditions:

1. "CAUTION RADIATION AREA" (Sign) - Required for areas where a major part of the body can receive a dose of 5 millirem/hour, or a dose in excess of 100 millirem in any 5 consecutive days. 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.

2. "CAUTION RADIOACTIVE MATERIALS" (Sign) - Required in areas/rooms in which radioactive materials are used or stored.

3. "CAUTION RADIOACTIVE MATERIAL" (Label) - Required on any container used to transport, store or use radioactive materials. Labels will also state quantities, kinds of materials, and dates of measurement of quantities.

4. "DANGER, HIGH RADIATION AREA" (Sign) - Required for any area where a major part of the body may receive in excess of 100 millirem in one hour.

5. Signs are also required for airborne radioactivity areas (consult the Radiation Safety Officer for specific conditions). Signs should not be used when they are not required.

6. Emergency Procedures and phone numbers of the RSO and principal investigator (Appendix J) will be posted in all radioisotope use areas.

III. RADIOISOTOPE USE

A. Application Procedures and Authorization for Use of Radioisotopes

1. Radioactive materials exempt from licensing (e.g. 3H exit signs) and sold to the general public: No person may use, or bring onto the Boston College campuses, radioisotopes in any amount without notification of the Radiation Safety Officer. ***Do not use radioactive materials when acceptable non-radioactive alternatives are available.***

2. Authorization for holding and using radioisotopes is given to designated individuals, Principal Investigators (referred to as PI or user), who must be full-time faculty members of Boston College and 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 of radioisotopes and modifications of existing authorizations must be submitted in writing to the Radiation Safety Officer, who may approve the use on an interim basis (Appendix N). The RSO will forward the proposal, with comments and recommendations, to the Radiation Safety Committee for review and approval at the next RSC meeting.
4. 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.
5. Authorization and Permits for use will be effective for five (5) years from the date of approval by the Radiation Safety Committee, and will cover ONLY 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 requests are approved by the Radiation Safety Officer to ensure that the order is within University and laboratory inventory limits.
6. All users and workers must complete the Radiation Safety Worker Registration Form (Appendix M) at the time of initial Radiation Safety Training at Boston College. Users (PIs) must attach this form to the Principal Investigator Application Form (Appendix N).

B. Responsibilities and Duties of Radiation Principal Investigators (Users) and Workers

Users of radioisotopes are individually accountable for compliance with government regulations and University conditions of use regarding the radioisotopes in their possession.

1. General responsibilities and duties of Principal Investigators are to:

   a. Ensure that new personnel report to the Radiation Safety Officer for certification and appropriate training prior to handling ionizing radiation. Dosimetry devices will be issued, as appropriate, by the department only following worker certification by the RSO.

   b. Ensure that:

      i) any person handling ionizing radiation under their supervision receives written safety protocols, is properly trained, and demonstrates that they understand the protocols

      ii) that appropriate protocols for handling these radioisotopes are on file with the RSO (Appendix N)

   c. Maintain up-to-date inventory logs of receipt, use, disposal, transfer, and storage for radioisotopes in their possession (Appendix U). These records and regular survey reports must be available for inspection by the Radiation Safety Officer at all times. Ensure that current quantities in lab do not exceed authorized maximum levels.

   d. Post on-site in each authorized location:

      i) Name and telephone numbers of the Principal Investigator and any designated lab contacts;

      ii) Rules, conditions, and instructions regarding the use of authorized radioisotopes;

iii) Emergency procedures to be followed in the case of spills, fire, or natural disaster, and personnel contamination or ingestion of radioactive materials (Appendix J);

iv) Contact information for the Radiation Safety Program.

f. Ensure the availability of a survey meter and/or Liquid Scintillation Counter to monitor personnel exposure and surface contamination.

2. General responsibilities and duties of both Principal Investigators and radiation workers are:

a. To avoid unnecessary exposure, either to themselves or to others under their supervision. Maintain all exposures As Low As Reasonably Achievable (ALARA).

b. To perform required monitoring tasks (self monitoring, *etc*.), as noted in this policy and, any additional monitoring tasks that should be directed by the Radiation Safety Officer or Radiation Safety Committee.

c. In accordance with the BC Radiation Safety Policy for Pregnant Women (see Appendix P, Prenatal Radiation Exposure), it is the responsibility of any woman who is pregnant or may be in the process of conceiving, *if she so chooses*, to request in writing that Boston College assist in limiting her occupational radiation exposure.

C. Termination of Work with Radioisotopes

If a PI determines s/he will no longer use radioactive materials, s/he should notify the Radiation Safety Officer or the departmental representative to the Radiation Safety Committee. Areas which are planned to be returned to general, unrestricted use must be surveyed by the Radiation Safety Technician. Until the survey and the lab termination form are completed, the lab will be considered to be active and must be managed by the PI as such.

IV. TRAINING AND RECORDKEEPING

A. TRAINING

1. Before the Principal Investigator purchases or introduces radioactive materials into the lab, all users and workers in the lab must receive Radiation Safety Training at Boston College, whether or not their work requires the use of radioactive materials.

   Initial training is a two hour course and covers the following areas:

   - Background Information - Radiation & types of radiation
   - Radiation Safety Program - Organization
   - Rules & Regulations
   - Use & Storage Locations at Boston College
   - Postings & Warnings for work areas
   - Health Effects
   - ALARA - As Low As Reasonably Achievable
   - Protective Devices
   - Reporting Responsibilities
   - Prenatal Exposure

2. Refresher training
   All users and workers must attend Annual Refresher Training. This is a half-hour course that reviews updates and changes to the program as well as, rules and regulations for use of radioactive materials at Boston College.

3. Additional training
   The Environmental Health and Safety Office is available to provide Awareness Level Training to members of the Boston College Police Department and the Facilities Services, Housekeeping staff who work in buildings where radioactive materials are used.

B. Recordkeeping

The Environmental Health and Safety Office maintains the following records:

- The Boston College Radiation License
- User applications – PI Protocols
- Radiation worker registration forms
- Training documentation: sign-in sheets for initial, refresher and awareness training, courses, quiz results, and radiation work registration forms
- Quarterly and annual dosimetry reports
- Prenatal exposure training records
- Monthly/Weekly survey reports
- Annual program audit reports
- All pertinent radiation waste documentation
- Decommissioning records of labs and equipment
- Records of incidents/exposures
- Current Inventories
  - Isotopes
  - Sealed sources
  - X-ray equipment
- Inventory of GM counter and calibration records

V. STANDARD PROCEDURES

A. Ordering, Delivery, Handling and Storage of Radioisotopes

1. Ordering Materials

Prior to purchase, authorized users will submit all orders for radioisotopes (Appendix X. Radioactive Material Order Form) signed by the PI or other authorized individual, to the Radiation Safety Officer (via pdf email to eric.johnson.5@bc.edu. The RSO will confirm that the user's lab isotope limits are not exceeded. The RSO will sign the request indicating approval, and return it to the user. The user will then give the order form to the person designated to order radioisotopes for the department. In the event that the RSO is not available, the user can forward the request to the Director of EHS/ARSO (Gail Hall) at gail.hall@bc.edu.

2. Delivery of Materials

All radioisotopes must be delivered to the Higgins loading dock/receiving room (H170D) to be leak-tested prior to delivery to the addressee by the RST. Operations or administrative staff must sign for all deliveries.

Packages that show measurable contamination above background upon wipe testing must be decontaminated and stored for 24 hours prior to re-testing for surface contamination.

Packages are to be opened by the RST according to the procedure described in Appendix G, Procedures and Forms for Safely Opening Packages, and documented on the form.

3. Material Handling (also see Appendices B through H).

a. Each user is responsible for the availability of proper equipment (laboratory handling equipment, shielding, hoods), and protective clothing (gloves, coveralls, shoe covers, etc.) prior to the start of work with radioisotopes.
b. Whenever possible, all work should be done in trays lined with absorbent materials to avoid contamination of permanent laboratory bench tops.
c. All persons working in areas where radioisotopes are contained or used must wash hands thoroughly before leaving the work area. Hand, shoe and area counts are required at the completion of daily operations.
d. Eating, storing or preparing food is forbidden in areas where unsealed radioactive sources are located or worked on. Smoking is also prohibited in all academic and administrative buildings.
e. NEVER pipette radioactive liquids by mouth.

4. Storage of Materials

a. Materials requiring a "Radioactive Materials" label will be stored only in areas that provide protection against fire, explosion, flooding and theft. The Radiation Safety Officer or Technician must approve such areas These areas are to be kept locked and under the supervision of an authorized PI.
b. Materials will be stored in suitable containers and direct radiation from the containers must not create a "Radiation Area." Appropriate shielding should be provided to insure this condition.
c. Prolonged storage of source radioisotopes in individual user laboratories in excess of normal research needs is prohibited.
d. Area signs must be posted and containers of materials properly labeled.
e. The Radiation Safety Officer must be informed of and approve any transfers of radioactive materials between labs to ensure that inventory limits are maintained. All transfers must be logged into the appropriate inventory forms.
f. A detailed log of receipt and disposal of materials (Appendix. U., Radioactive Nuclide Inventory) will be maintained for each storage area indicating receipt date, source, level and nature of each radioisotope container.

B. Wastes: Storage and Disposal

Radioactive wastes must be stored only in restricted areas in the labs. taken to the Radioactive Waste Storage Room and stored until disposal. See Appendix Q, Boston

College's *Proper Segregation, Minimization and Disposal of Radioactive Wastes* for more details.

1. Liquid Waste Management (Also see Appendix Q)

a. Liquid waste may be sink-disposed within the limits of Table 3 of Appendix C of this manual, provided the waste is readily soluble or dispersible in water. In general, repetitive flushing with water should follow sink disposal. Where necessary, a single sink will be designated for the disposal of radioactive waste. Sinks will be posted as needed with approval from the RSO. A log of all waste disposals **MUST** be kept recording date, amount, activity, and the person responsible.
b. If liquid waste cannot be sink-disposed, it should be absorbed or solidified with appropriate materials. If a lab produces large quantities of radioactive liquid waste (e.g. HPLC waste) they should notify Radiation Safety in the planning stages prior to production of the waste. Mixed waste (radioactive RCRA hazardous waste) should not be absorbed; Radiation Safety should be notified prior to generation of this waste. No unabsorbed liquid wastes is to be disposed of with solid wastes.
c. Inorganic, biodegradable, water soluble liquid scintillation cocktails (LSF) may be disposed of down the designated sink as long as they meet the criteria outlined in Table 3 of Appendix C of this manual. The amount of radioactivity must be logged on the sink disposal log.
d. The use of *organic* liquid scintillation cocktails is prohibited at Boston College, and workers should avoid generating organic radioactive liquids from an experiment. If generated, these wastes must be disposed of as mixed radioactive and chemical hazardous waste. Short-lived and long-lived organic liquid wastes must be separated.
e. All liquid radioactive waste with a half-life <120 days that can be absorbed should be, and will be collected by the RST and stored for decay in the radiation waste room. If it cannot be absorbed for specific reasons it will still be collected by the RST and stored for decay in the rad waste room. After 10 half-lives it will be analyzed and disposed of as chemical hazardous waste through the RCRA Hazardous Waste Program.
f. Long lived isotopes in organic liquids should be avoided at all costs. Disposal options are limited and costly. If possible, treat waste to separate radioactivity from liquid either by carbon filtration or ion exchange. Combine untreatable waste with an absorbent solid material, such as vermiculite, and separate from all other radioactive solid waste. Label as long-lived radioactive/hazardous waste.
g. Liquid Scintillation Fluids (LSF) can be left in the vials for disposal. This method is preferred. The vials should be bagged and labeled with the radioisotope and activity and will be picked up by the RST. ^{3}H and ^{14}C vials should be separated from all other vials. Vials with activities < 0.05 µCi/gram will be shipped as non-hazardous waste with a chemical waste disposal company. All other isotopes that cannot be decayed on site will be shipped as regulated scintillation vial waste to an appropriate vendor.

2. Solid Wastes Summary (Also see Appendix Q, Proper Segregation, Minimization and Disposal of Wastes)

a. Wastes should be segregated by the user so that only those necessary to dispose of as radioactive wastes are included in the radioactive solid waste container. Limits for disposal with normal trash are given in Table 4 of Appendix C.

b. Whenever possible, isotopes with relatively short half-lives, such as 32P, 35S, 125I, 99Tc, etc., should be allowed to decay in storage for a period of at least 10 half-lives. ONLY the RST can dispose of decay-in-storage waste. Bag and label the waste and arrange for pick-up.

c. Transportation of solid waste from the user laboratory to a central disposal point will be performed by the RST.

d. An up-to-date waste log will be maintained by the RSO/RST showing addition and disposition of solid wastes from pick-up in user waste areas to disposal by vendor or decay. Source information should include laboratory of origin, nature, activity and quantity of waste; disposal will be recorded as approximate upper limits discharged to the commercial vendor.

C. Decommissioning Laboratories and Equipment

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 and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material", 1987. For ß and γ-emitters average surface contamination levels should be below 5,000 dpm/100 cm^2 with removable levels less than 1,000 dpm/100 cm^2 (see Appendix C, Table 4)

The Radiation Safety Officer must be informed prior to the termination of any use of radioisotopes. Areas that are planned to be returned to general, unrestricted use, must be surveyed by the RSO beforehand. Laboratory areas and equipment (including hoods, sinks, refrigerators, freezers, centrifuges, glassware, shielding, storage containers, bench tops, cabinets, and floors) shall be decontaminated or disposed of by the terminating user as approved by the RSO or RST. Equipment and areas that 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, the Radioactive Materials signs will be removed from the laboratory entrances and storage areas by the RSO or RST. Documentation of decontamination surveys and laboratory clearance will remain on file at the Office of Environmental Health and Safety for a period of five years.

VI. EMERGENCY PROCEDURES

A. Contamination and Spills

In the event of a spill, the first thing to do is to assess the size of the spill, both in volume/area and radioactivity. It is convenient to classify spills as minor or major. As a guideline, a minor spill has less than 100 μCi, and in fact, most spills will be minor. The procedures follow:

1. Minor Radioactive Spills (≤100 µCi)

The individual responsible for the spill is responsible for its decontamination. It is the Permit Holder's responsibility to ensure there are adequate personnel to assist in the cleanup.

- *NOTIFY*: Notify persons in the area that a spill has occurred.
- *PREVENT THE SPREAD*: Drop absorbent media or paper towels on the spill, and on any visible liquid, to limit the spread of contamination; do not wipe or smear the liquid, to avoid spreading contamination. Do not allow anyone to leave the area without being monitored.
- *MARK OFF THE AREA:* Wear disposable gloves, a lab coat, shoe coverings (for a floor spill) and remote handling tongs. Use a survey meter (or liquid scintillation counter for 3H) to determine how far the contamination has spread. Promptly mark off the area of the spill using tape. Since defacing radioactive tape after cleanup may be impractical, other colored tape may be used as long as everyone is aware that the tape is marking off a radioactive spill.
- *CLEAN UP:* Carefully pick up the absorbent paper and wipe up any visible radioactive liquid with fresh paper. Place cleaning materials and all other contaminated materials (such as disposable gloves) in a labeled plastic bag for disposal in the radioactive solid waste container.
    - i. Normal cleaning agents should be adequate, or use "Count-Off". Keep cleaning supplies to a minimum.
    - ii. While cleaning, control the spread of the contamination by isolating higher activity spots and scrub spots of lower contamination first. Wipe or blot inward, from low activity to higher activity areas.
    - iii. If the area is still contaminated apply a spare amount of diluted detergent onto contaminated spots and allow it to soak the spot for a few minutes, then wipe it up.
    - iv. If cleaning large areas of radioactivity, work on a 1-foot x 1-foot square at a time. If necessary, use a more abrasive material such as steel wool to scrub the area. Never use any detergents or cleaners (such as bleach) that may volatilize the radioactivity.
- *NOTIFY THE PRINCIPAL INVESTIGATOR AND THE RADIATION SAFETY OFFICE.*

2. Major Radioactive Spills (more than 100 µCi)

a. Call the Radiation Safety Officer (617-552-0363) or Boston College Police Department (617-552-4444) and ask them to contact the on-call EHS staff member. If necessary, Campus Police will assist in controlling access to the spill area.
b. Do not attempt to decontaminate the area until qualified radiation safety personnel have arrived. If the spill area is localized, cover the area with absorbent paper.
c. Skin contamination takes priority over cleaning the spill area. To avoid tracking the material around, remove contaminated shoes, lab coats, and other clothing and leave it at the laboratory door. Proceed to a nearby uncontaminated control area and decontaminate the skin by flushing the area thoroughly (for approx.. 15 mins.) and then washing with a mild soap and warm water.
d. Do not leave the control area until Radiation Safety has determined the extent of the hazard and until the area has been thoroughly surveyed.

e. In general, decontamination is conducted as for minor spills. However, Radiation Safety must first evaluate the circumstances of the spill prior to instructing staff in the decontamination plan.

The maximum limits suggested for fixed contamination on hands, body surfaces, personnel clothing and shoes are:

Alpha activity - 100 dpm /100 cm^2
Beta or gamma activity - 0.1 mrad/hr at 2 cm, 22 dpm/cm^2

3. Accident Reports

All accidents involving possible individual or area contamination must be reported immediately to the Radiation Safety Officer or to the departmental representative to the Radiation Safety Committee, who in turn will inform the Radiation Safety Officer.

VII. X-RAY DEVICES

The state Department of Public Health regulates the use of x-ray machines in 105 CMR 120.600 of its Radiation Safety Regulations. These regulations demand that a device be attached which prevents the beam from striking anyone entering the beam path or shuts off the beam should someone enter the path. In an open beam configuration, each port on the radiation source housing shall be equipped with a shutter that cannot open unless a collimator or coupling has been connected. Any unused ports should be closed in a secure fashion. Each x-ray tube housing shall be equipped with an interlock that shuts the tube off if it is removed from the housing. No work shall be done on the x-ray source without ascertaining that it has been turned off.

The room should be posted with a sign bearing the radiation symbol and the words *CAUTION - X-Ray Equipment*. The x-ray equipment should be labeled with *CAUTION - High Intensity X-Ray Beam* on the source housing and *CAUTION - This Equipment Produces Radiation When Energized* near any switch that turns on the x-ray tube. Open beam configurations should also have an *on-off* status sign located near the beam source or an *open-closed* indicator for each port. An *X-Ray ON* warning light near the switch that energizes the x-ray tube should illuminate when the tube is on. All types of warning devices should be fail-safe. A disabled safety lock should be labeled with *Safety Device Not Working*.

With all shutters closed the radiation measured at a distance of 5 cm from its surface is less than 2.5 mrem (0.025 mSv) in one hour. The cabinet of each x-ray generator shall limit radiation measured at 5 cm to less than 0.25 mrem (2.5 µSv) in one hour. The components of the x-ray system shall be located and sufficiently shielded so that no radiation significantly above background shall exist in surrounding areas. Radiation surveys shall be done upon installation and annually thereafter to ensure that these levels are not exceeded (see Appendix V., X-ray Machine Annual Monitoring Record). Should the configuration be added to or changed, disassembled, or appear abnormal or personnel monitoring devices show a significant increase in radiation, a survey shall be performed.

The Principle Investigator responsible for each X-Ray device is responsible for completing Appendix S. Authorization to Possess and Use Equipment that Produces Ionizing Radiation and submitting this form to the Radiation Safety Officer for review and approval. Written operating procedures should be available to all personnel. Procedures shall include the requirement for laboratory workers to perform periodic radiation surveys of the equipment. These procedures must be adhered to and no individual shall be allowed to bypass a safety device or interlock, without the approval of the RSO.

All persons using x-ray equipment shall have received instruction and demonstrated competence as to: 1) Identification of radiation hazards, 2) Significance of the warning signs and safety locks, 3) Proper operating procedures, 4) Recognition of symptoms of acute localized exposure to radiation, and 5) Procedures for reporting exposure. Use of finger or wrist dosimeters **may be required for** personnel using the x-ray equipment. A record of personnel training should be maintained and filed with the RSO (see Appendix N).

Changes in the location of x-ray equipment shall be reported to the RSO**.**

APPENDICES

APPENDIX A. Glossary of Terms

ABBREVIATIONS: RSC - Radiation Safety Committee; RSO - Radiation Safety Officer; ARSO – Associate Radiation Safety Officer; RSM - Radiation Safety Manual; RST - Radiation Safety Technician; NRC – Nuclear Regulatory Commission; DPH – Department of Public Health; EHS – Environmental Health & Safety.

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 practical 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.

BECQUEREL (Bq): The SI unit of activity in disintegrations per second (s^{-1}). (1 Ci=$3.7x10^{10}$ 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 ($H_{T,50}$): 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 ($H_{E,50}$): 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. Contamination's 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 3.7000 x 10^{10} per second. Abbreviated Ci. Millicurie: One-Thousandth of a curie (3.7 x 10^{7} disintegrations per second or 2.22 x 10^{12} 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 (H_d): External whole body exposure, the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

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 x 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 x 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 election 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 radiation. 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. Effective half-life=(Biological half-life x Radioactive half-life) / (Biological half-life + 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. 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.

LABELLED COMPOUND: A compound consisting, in part, of labeled 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 sub multiple 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)

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 = 2.58×10^{-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 photo multiplier 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/cm^2) averaged over an area of 1 cm^2.

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

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 extra nuclear 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. Secure all areas where radioactive materials are used/stored when unattended

6. 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.

7. Wear finger ring badges when handling one milliCurie or greater ^{32}P or other energetic beta-emitters.

8. Dispose of radioactive waste only in specially designated receptacles.

9. Store radioactive materials correctly and assure all material containers, equipment, and work areas where radiation is used are labeled properly.

10. Never pipette by mouth.

11. Confine radioactive solutions in covered containers plainly identified and labeled with name of compound, radionuclide, date, activity, and radiation level, if applicable.

12. Always transport radioactive materials in shielding containers and always use shielding when working with radioactive materials in the lab.

13. Use absorbent material on bench tops/working surfaces where radioactive materials are used

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/cm^2 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 ^{32}P-beta is 1.71 MeV x 12 ft/MeV = 20 ft).

d. 1/4 inch of lucite will attenuate the air dose rate of ^{32}P and other energetic beta particles by a factor of more than 200X.

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 µCi/cm^3 (in water) is 1.48 rads/hr).

f. For β-particles the surface dose rate through the nominal protective layer of the skin (7 mg/cm^2) from a uniform thin deposition of 1 µCi/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 β radiation (neglecting self and air absorption) of known activity in milliCuries (mCi), the dose rate (D) in rads per hour at 1 ft is given by the equation D=300 x (# mCi). This varies only slightly with beta energy. (Dose rate for 1 mCi ^{32}P at 1 cm is approximately 300 rads/hour).

Gamma irradiation

a. For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate in mR/hr ±20% at 1 foot is: *6 x mCi x E x n*, where mCi is the number of milliCuries, *E*, the energy in MeV; and *n*, the number of gammas per disintegration.

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 µCuries 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.

APPENDIX C. Useful Tables

Table 1. Airborne Contamination Limits for Common Radioisotopes

Isotope	ALI* in µCi
^{14}C	$2x10^3$
^{3}H	$8x10^4$
^{35}S	$2x10^4$
^{131}I	$5x10^1$
^{125}I	$6x10^1$
^{32}P	$9x10^2$
^{45}Ca	$8x10^2$
^{24}Na	$5x10^3$
^{42}K	$5x10^3$
^{51}Cr	$2x10^4$
^{36}Cl	$2x10^3$
^{99}Tc	$7x10^2$

***ALI = Annual Limit on Intake (See Glossary of Terms for definition)**

Table 2. Minimum Quantities Requiring Signs or Labels (Selected Radioisotopes)

Isotope	Signs on Rooms* µCi	Labels** µCi
^{14}C	10,000	1000
^{3}H (HTO, $^{3}H_{2}0$)	10,000	1,000
^{45}Ca	1000	100
^{60}Co	10	1
^{36}Cl	100	10
^{51}Cr	10,000	1,000
^{137}Cs	100	10
^{64}Cu, ^{55}Fe	10,000	1000
^{59}Fe	100	10
^{131}I	10	1
^{125}I	10	1
^{24}Na, ^{32}P	100	10
^{35}S	1,000	100
^{90}Sr	1	0.1
^{99}Tc	1000	100

*Signs are not required on rooms in cases where radioisotopes will be in the room for less than 8 hours provided that (1) the materials are **constantly** attended by an individual who will take necessary precautions to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations; (2) the room is under the authorized user's control.

Table 3. Maximum Concentrations of Radioisotopes Permissible for Sink Disposal (Selected Radioisotopes)

*Soluble Forms Only**

(Note that sink disposal log entries must not exceed these limits. [10 CFR 20.2003])

Isotope	Maximum Daily Laboratory Sink Disposal Limit µCi
^{14}C	100
^{3}H	1000
^{125}I	1
^{131}I	1
^{32}P	10
^{33}P	100
^{35}S	25
^{99}Tc	50
^{103}Ru	100
^{106}Ru	10

Daily laboratory limits in µCi were calculated based on the "Monthly Average Concentration in µCi/ml" from Table 3, Appendix B, as well as requirements in Section 20.2003, 10 CFR, Part 20, Chapter 1 of NRC Rules and Regulations. Laboratory limits are based on a 500,000 gallon/day discharge from the campus, the number of laboratories and users using a particular isotope, and assumes that all laboratories are disposing of the maximum daily amount (listed above) 365 days/year.

* Only readily soluble (or readily dispersible biological) material can be sink disposed. See NRC Information Notice 94-07, "Solubility Criteria for Liquid Effluent Releases to Sanitary Sewerage Under the Revised 10 CFR Part 20" which was distributed to all laboratories in January 1994 and is available from the RSO.

Dilute all isotopes for sink disposal as appropriate so that radiation exposure from the diluent is below 2 mRem/hr.

Table 4. Acceptable Surface Contamination Levels for β and γ-emitters

Nuclides[2a]	Average[3b,4c,f]	Maximum[b,5d]	Removable[b,6e,7f]
Unat, ^{235}U, ^{230}U and decay products	5,000 dpm a/100 cm^2	15,000 dpm a/100 cm^2	1,000 dpm a/100 cm^2
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac, ^{125}I, ^{129}I	100 dpm/100 cm^2	300 dpm/100 cm^2	200 dpm/100 cm^2
Th-nat, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{133}I	1000 dpm/100 cm^2	3000 dpm/100 cm^2	200 dpm/100 cm^2
B-γ emitters (nuclides with decay modes other than α-emission or spontaneous fission) except ^{90}Sr, U and transuranics.	5000 dpm β-γ /100 cm^2	15,000 dpm β-γ /100 cm^2	1000 dpm β-γ /100 cm^2

Notes:
1) Where surface contamination by both alpha and beta-gamma emitting nuclides exists, the limits established should apply independently.
2) As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the cpm (counts per minute) observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
3) Measurements of average contamination should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.
4) The maximum contamination level applies to an area of not more than 100 square cm.
5) The amount of removable radioactive material per 100 square cm of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionately and the entire surface should be wiped.
6) The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr. at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 mg/square cm of total absorber.

[2a] Where surface contamination by both α and β-γ -emitting nuclides exists, the limits established for the α and β-γ -emitting nuclides should apply independently.

[3b] As used in this table, dpm means the rate of emission as determined by correcting the cpm observed by an appropriate detector for background, efficiency and geometric factors.

[4c] Measurements of average contamination should not be averaged over more than 1 m^2. For objects or less surface area, the average should be derived for each object.

[5d] The maximum contamination level applies to an area not more than 100 cm^2.

[6e] The amount of removable material per 100 cm^2 should be determined by wiping that area with dry filter paper of soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[7f] The average & maximum radiation levels on the surface from β-γ emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured not more than 7 mg/cm^2 of total absorber.

APPENDIX D. Workplace Standards for Operations with Unsealed Radioactive Material

All operations with unsealed radioactive materials at Boston College 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 BC 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.

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, dessicators, or designated and labeled refrigerators and freezers.

5) Personnel shall wear lab coats, 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.

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 between 80-120 fpm (feet per minute) with the sash 80% open.

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

Type C - Radioisotope Laboratory
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.

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 Boston College 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.

II. In order to determine the type of workplace required for a particular operation, the relative radiotoxicity of the radioisotope, the physical and chemical form of the material, and the type of manipulations must all be considered. The following analysis is to be considered a guideline for determining minimum workplace requirements for work with a given quantity of material.

If a detailed analysis of a specific experiment and laboratory reveals circumstances not covered in this guide, the Radiation Safety Committee or Radiation Safety Officer may increase or decrease the quantities allowed in a given workplace type.

The following equation is to be used to determine the effective quantity of a radioisotope in a given operation.

$$Q_{eff} = QAH$$

where Q_{eff} = Effective quantity in millicuries; Q = Actual quantity in mCi; A = Action factor; H = Hazard factor.

Q_{eff} is the quantity ultimately used to determine the type of workplace required for a given class of radioisotope. The classes of radioisotopes are determined by the relative radiotoxicity of the radioisotope listed in Appendix C of this manual.

Q is the actual quantity of radioisotope used in the operation.

A is a factor to account for the overall probability that radioactive material may be released to the environment and subsequently inhaled or ingested. This factor involves consideration of the complexity of manipulations and the potential energy released in the operation (i.e. highly exothermic reactions, heating, grinding).

H is a factor to account for additional hazards which exist due to the physical or chemical form of the radioactive material (i.e. nucleic acids, nucleic acid precursors, gases, fine powders, carcinogens, toxins, explosives, aerosols, etc.)

Table I lists action factors and Table II lists hazard factors. When each of the factors applicable to a given experiment has been determined, Q_{eff} can be calculated. Table III is then used to determine the type of workplace required for a particular class of radioisotope.

Table I. Action Factors

Type of Operation	Action Factor
Storage	0.01
Very simple, wet operation (Diluting stock solutions, sealed ultra centrifugation solutions, sealed ultra centrifugation washing precipitates, *in vitro* incorporation/incubation, etc.)	0.1
Normal wet chemistry (Precipitation, filtration, bench type centrifugation solvent extraction, chromatography, pipetting or titrating-includes aliquoting stock solutions)	1
Animal injections, complex wet operations (distillation, homogenization, evaporation to dryness). Simple dry operations with non-respirable particles (Fusion reactions, fluorination, transfer of dry precipitates, etc.)	10
Operations which may produce respirable size particles (Dry powders, gaseous except tritium and noble gases, aeration of liquids, use of highly volatile liquids or highly exothermic reactions)	100

Table II. Hazard Factors

Material	Hazard Factor
Insoluble or non-metabolizable liquids, solids, or gases	0.1
Metabolizable organics or inorganics	1.0
Nucleic acids and precursors (*Not* ^{32}P-phosphates.) Skin permeable liquids (DMSO tritiated water, high specific activity (100 mCi/ml) radioactive materials)	10.0
Carcinogens, explosives, extreme toxins	100.0

Table III. Workplace Effective Maximum Radioisotope Quantity as a Function of Toxicity Class

	WORKPLACE TYPE			
Radionuclide Toxicity Class*	**A**	**B**	**C**	**D****
Very High	0.1 µCi	10 µCi	100 µCi	Greater than C quantity
High	1 µCi	100 µCi	1 mCi	"
Moderate	10 µCi	1 mCi	10 mCi	"
Slight	100 µCi	10 mCi	100 mCi	"

* See Appendix C, Table 4.

** Work requiring a Type D workplace may upon, exception granted by the RSC, be performed if an adequate Type C workplace is used, written procedures are approved in advance, and the work is done under the supervision of a member of the Radiation Safety Committee.

APPENDIX E. Radiation Surveys

1. Radiation Levels

Monitor area with a radiation survey meter sufficiently sensitive to detect 0.1 mRem/h. The results of this survey should be recorded on a standard form (Appendix X: Radiation Safety Inspection Worksheet) which should show:

a. Location, date, and type of equipment used.
b. Identification of person conducting the survey.
c. Utilizing posted sketch of area surveyed, identify 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.

A thin end window GM normally may be used for assaying beta emitters at or above C-14 energies; low energy beta emitters will require a gas flow proportional counter or liquid scintillation counting.

A gamma-scintillation counter (example: NaI well counter) should be used for pure gamma emitters. Make sure that the analyzer threshold is set below the lowest gamma energy used in the lab (usually I-125).

Record a background count using the same counting conditions used with the wipes.

In the case of wipes contaminated with gamma emitters, the radionuclide can be identified from successive counts with different analyzer settings if the settings have been calibrated with known energy standards.

3. Acceptable Limits;

Radiation Limits (Whole body only)

i. Non-controlled area **-** Personnel must not receive more than 2 mRem in any one hour or more than 100 mRem in any one year.

ii. Controlled area
   a. If an area is controlled for purposes of radiation protection, then an investigator's total exposure must be less than 5 Rem/year. On the basis of 40 hours/wk exposure, the maximum exposure rate would have to be less than

2.5 mRem/h. In practice, the radiation levels should be kept as low as reasonably achievable (ALARA) and always below applicable limits.

b. An individual wipe test should routinely cover approximately 100 cm^2. Ideally, any contamination more than a few mRem/hr above background should be cleaned up; however, a more usual level for beta or gamma radiation at which cleanup is initiated is 3 times background. At approximately 1 mRem/hr a "Contamination Zone" should be established until the contamination is removed. Contamination levels may also be estimated with a survey meter. As a rough rule of thumb, establish a Contamination Zone if readings are greater than 0.1 mRem/hr for Group I and II radionuclides and greater than 1 mRem/hr for Groups III and IV radionuclides when measured with a thin window GM meter. Of course, this particular instrument will not detect low energy beta emitters such as tritium.

c. Patterns of contamination consistently observed at several times background (usually between 0.2 and 1 mRem/hr) in periodic surveys should be noted and reported to the RSO and the principal investigator. The cause for this contamination should be determined and eliminated.

APPENDIX F. Bioassay Program

Bioassays may be employed to evaluate the exposure levels of individuals working with ^{125}I, ^{131}I, and ^{3}H. The basic procedures to be followed are as outlined in *Regulatory Guide 8.20: Applications of Bioassay for ^{125}I and ^{131}I* (April 1978) and *Regulatory Guide 8.8.32: Criteria for Establishing a Tritium Bioassay Program (July 1988).* Compliance with 105 CMR 120.214 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 105CMR 120.296: Appendix B, Table I, Columns 1 and 2; and
(2) minors and declared pregnant women likely to receive, in one year, a committed effective dose equivalent in excess of 0.05 rem (0.5 milliSievert).

The major features of the bioassay programs are as follows:

A. For users of ^{125}I or ^{131}I

I. Only materials already labeled with ^{125}I or ^{131}I 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 sources of ^{125}I or ^{131}I in excess of 1.0 mCi must notify the Radiation Safety Officer. These individuals must be monitored regularly if using greater than 1.0 mCi repeatedly or must submit to a thyroid scan within 10 days of the last use of greater than 1.0 mCi if using infrequently.

Note: Depending upon the nature of ^{125}I or ^{131}I 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 µCi ^{125}I or 0.04 µCi ^{131}I 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 ^{3}H

I. Any individual who will be using unsealed sources of ^{3}H 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 ^{3}H repeatedly or 2) within one week of the last use of greater than 50 mCi if use is infrequent..

Note: The nature of ^{3}H 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 ^{3}H activity greater than 5 µCi/1 will be prevented from continuing studies employing ^{3}H 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 ^{32}P - 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 and Form for Safely Opening Packages Containing Radioactive Material

To be performed ONLY by Radiation Safety Technician.

1. Visually inspect package for any sign of damage (e.g. wetness, crushed). If damage is noted, stop procedure and notify Radiation Safety Officer.
2. Measure exposure rate at 1 meter from package surface and record. If greater than 10 mRem/hr, stop procedure and notify Radiation Safety Officer.
3. Measure surface exposure rate and record results on form. If greater than 200 mRem/hr, stop procedure and notify Radiation Safety Officer.
4. Put on gloves.
5. 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 on form below.
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 filter paper, check wipes in the Liquid Scintillation Counter, 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.

RADIOISOTOPE SHIPMENT RECEIPT REPORT

PO# ______________________________ Survey Date: ___/___/___ Time: _______

Supplier: ___________________________ Surveyor___________________________
(PRINT)

CONDITION OF PACKAGE:
Good ______ Crushed ______ Punctured ______
Wet ______ Other (specify) ____________________

CONTENTS:
Isotope: _____________________

Chemical Form: _______________

Quantity: ________________(mCi)

Do vial contents and package slip agree? Yes ___ No ___
If no, specify nature of difference:

TEST RESULTS:
a) Test Type (x): Wipe ____Ludlum 3 S/N _____________ Cal. Date____
b) Backgrounds: Wipe______ DPM GM_______________mrem/hr
c) Outer Container: Wipe ______DPM Surface:____________mrem/hr
1 m:_____________mrem/hr
d) Final Source Container: Wipe ______DPM Surface: ___________mrem/hr
1m: _____________mrem/hr

PACKAGE DELIVERED TO: ______________________Dept.__________________

Building____________________________________ Room #________________________

RST/RSO /ARSO SIGNATURE: ____

RECIPIENT____
Signature Print Last Name

IF DPH/CARRIER NOTIFICATION IS REQUIRED, RECORD

Date: ___/___/___ Time: __________ Person Notified:______________________

APPENDIX H. *In Vivo* Labeling Studies Procedures

10/1/2012 - Boston College does not currently have any in vivo experiments being conducted. Prior to authorizing any such work the Radiation Safety Committee should review these procedures.

1. *In vivo* labeling experiments are to be conducted only by individuals whose protocols have been approved by *both* Radiation Safety Committee and the Institutional Animal Care and Use Committee (IACUC), 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 and the IACUC.

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 in a garbage grinder such that the concentrations of the pertinent radionuclide are within those specified for sink disposal. (*Not current procedure.)*

5. The investigator has direct responsibility for overseeing and manipulating the organisms carrying radioisotopes (and their cages and other materials) during the *in vivo* experiments. The management practices will be developed under the direction of the Director of Animal Facilities and the Institutional Animal Care and Use Committee (IACUC). Any individual who plans to use radioactive materials in *in vivo* studies must receive the approval of both the RSC and the IACUC.

Radioactive Nucleic Acids and Derivatives

Experiments involving the use of radioactive nucleic acids and radioactive nucleic acid derivatives presents a special hazard in that some of these compounds may become incorporated in the genetic material of the body cells. The following procedures have been adopted by the Radiation Safety Committee for 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.:_________

____Ext.:_________

____Ext.:_________

Brief Description of the Project____

____

Identity of Radioactive Material:_______________________

Source:___________________Storage Location:__________

Animals Proposed for Project:

Species_____________Strain________Quantity____________Proposed Date:______

Administration of Material per Animal: Preparation: ____________Dose:________

Frequency:__________Total Dose:_________Method of Administration:________________

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_______________

IACUC Protocol Number_________________Rad 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 Personal Protective Equipment is required 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 IACUC safety protocols for these substances.

Signature of the Principle Investigator____________________________Date:_______

FOR IACUC USE ONLY

Date Received:_________________

Space Assigned:________________

Animal Care Personnel Associated with Project Date Informed

____

____

____

Approval: ________________________ ______________________________
Animal Care Supervisor Radiation Safety Officer

APPENDIX I. Calibration of Survey Meters - Procedures and Frequency

A list of University meters and calibration due dates is maintained at the Office of Environmental Health and Safety.

Survey meters and associated probes will be collected when they are due for calibration by the RST and will be calibrated on site or sent to an outside vendor to be calibrated according to NRC and Massachusetts RCP guidelines.   Meters are calibrated for both exposure monitoring and contamination surveys.

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 researcher to notify the RST to have the meter calibrated on site or sent out for calibration. At this time it will be added to the meter calibration list.

If you wish to receive a copy of the calibration report for your meter and probe please be sure that your laboratory PI's name is on the meter, otherwise all reports will be reviewed by the RSO and filed in the Office of Environmental Health and Safety.

APPENDIX J. Notice to Workers in Radioisotope Use Areas

The following notice and the Massachusetts Notice to Employees will be posted in all radioisotope use areas.

Radiation Safety Officers

Gail Hall, Associate RSO 617-552-0300

Eric Johnson, RSO 617-552-0363 or 781-964-3949

BCPD Emergency # 617-552-4444

Laboratory Supervisor:_____________________________Phone# office___________cell/home_____________

A. Minor Spills

1. *NOTIFY*: Notify persons in the area that a spill has occurred.
2. *PREVENT THE SPREAD*: Cover the spill with absorbent paper.
3. *MARK OFF THE AREA:* Do not allow anyone to leave the area without being monitored.
4. *CLEAN UP*: Use disposable gloves and remote handling tongs. Normal cleaning agents should be adequate or use "Count-Off". Keep cleaning supplies to a minimum. Proceed from the outermost edges of the contaminated area inward. Insert cleaning materials into a plastic bag and dispose of in the radioactive waste container. Also insert into the plastic bag all other contaminated materials such as disposable gloves.
5. *SURVEY*: With a low-range, thin-window G-M survey meter, check the area around the spill, hands, and clothing for contamination.
6. *SUBMIT REPORT TO THE RADIATION SAFETY OFFICE*R.

B. Major Spills

1. *CLEAR THE AREA*: Notify all persons not involved in the spill to vacate the room.
2. *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.
3. *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.
4. *CLOSE THE ROOM*: Leave the room and lock the door(s) to prevent entry.
5. *CALL FOR HELP*: Notify the Radiation Safety Officer immediately and call Campus Police.
6. *PERSONNEL CONTAMINATION*: Contaminated clothing should be removed and stored for further evaluation by the Radiation Safety Officer. If the spill is on the skin, flush thoroughly and then wash with mild soap and lukewarm water.

C. Accident Reports: All accidents involving possible individual or area contamination must be reported immediately to the Radiation Safety Officer.

D. Log Book: Maintain binder of all inspection reports, shipment receipt reports, and up-to-date isotope log sheets.

Parts 10 CFR 19 and 10 CFR 20, "Rules and Regulations", U.S. Nuclear Regulatory Commission (NRC) and copies of the Boston College License and appendices thereto, together with all relevant correspondence from the NRC are kept on file in the Office of Environmental Health and Safety at St. Clement’s Hall, and are available to all personnel on request. Also available are the Commonwealth of Massachusetts regulations 105 CMR 120; associated documents which support the license; and any notices of violations involving radiological working conditions, proposed imposition of civil penalty, or order pursuant to 105 CMR 120.001, and any response from the licensee or registrant.

NOTICE TO ALL PERSONNEL WHO WORK WITH RADIOACTIVE MATERIALS

This notice is issued to comply with the provisions of Section 120.752 (B) of the Commonwealth of Massachusetts Department of Public Health 105 CMR. Current copies of the following documents are available for examination at the Office of Environmental Health and Safety, St. Clement’s Hall.

105 CMR 120.750 NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS: INSPECTIONS

“105CMR 120.750 establishes requirements for notices, instructions and reports by licensees or registrants to individuals engaged in activities under a license or registration and options available to such individuals in connection with Agency inspections or licensees or registrants to ascertain compliance with the provisions of M.G.L.c. 1111, paragraphs 3, 5M, 5N, 5O, and 5P and regulations, orders and licenses issued thereunder regarding radiological working conditions. 105 CMR 120.750 applies to all persons who receive, possess, use, and transfer sources of radiation registered with or licensed by the Agency pursuant to 105 CMR 120.020 and 105 CMR 120.100.”

105CMR 120.200 STANDARDS FOR PROTECTION AGAINST RADIATION “105 CMR 120.200 establishes standards for protection against ionizing radiation resulting from activities conducted pursuant to licenses or registrations issued by the Agency. The requirements of 105 CMR 120.200 are designed to control the receipt, possession, use, transfer, and disposal of sources of radiation by any licensee or registrant so the total dose to an individual, including doses resulting from all sources of radiation other than background radiation, does not exceed the standards for protections against radiation prescribed in 105 CMR 120.200.”

APPENDIX K. Suggested RSC Meeting Agenda Items

The following items should be covered at least annually at RSC meetings:

1. Minutes of previous meeting.

2. Review of new user applications, changes to protocols, and Radiation User protocols up for review.

3. Report by the RSO on periodic review of dosimetry reports to identify any reported exposures which require additional investigation or response or that exceed the limits set forth in Section II of this manual.

4. Each year the RSC will review the Radiation Safety Manual/Program

5. Review results of monthly/weekly area surveys. Discuss results of the semi-annual inspection of radioisotope use sites.

6. Discuss status of the Radioactive Waste Program at Boston College.

   - Low Level Radioactive Waste survey (Annual Report to State)
   - Report on waste shipments throughout the year
   - Status of the storage facilities for radioactive waste

7. Verify that holdings of radioisotopes are within licensed limits. Review limits for individual users.

8. Review/Discussion of Annual Program audit

9. Discussion of any lab, designated radiation area, or equipment that has been decommissioned.

10. Discussion of any incidents that may have occurred and either effect or are related to the Radiation Safety Program.

11. Check that quarterly wipe tests of sealed sources have been done.

12. Check that the annual calibration of monitoring devices has been accomplished.

13. Annual survey of X-Ray equipment

14. Review of trainings taking place throughout the year

APPENDIX M. Radiation Worker Registration Form

BOSTON COLLEGE
OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY
RADIATION SAFETY PROGRAM

WORKER REGISTRATION FORM

SECTION I Date ____________________

1. Name ____
(Print) Last First M.I.

2. Social Security Number (last 4 digits) ______________________Birth Date _________

3. Department ____________________ Supervisor ____________________

4. Faculty ___________ Staff _______ Student ___________Other _______

Title ____

5. Office No. ____ Ext. ________ Lab No. ___________Ext. ________

6. Project Supervisor (PI) __________________________________

7. Brief description of work with radiation:

8. Radioactive material to be used in your work:

RADIONUCLIDE(s)	TOTAL ACTIVITY ORDERED (MCi)	CHEMICAL OR PHYSICAL FORM ORDERED	MAXIMUM AMOUNT USED PER EXPERIMENT

9. Radiation producing equipment to be used in your present work:

Type ____________________ Maximum Energy_________________________

Radiation Safety Program Worker Registration Form, cont'd

SECTION II PREVIOUS EXPERIENCE WITH RADIATION

1. Previous Experience with radioactive material:

RADIONUCLIDE(S)	GREATEST ACTIVITY USED

EMPLOYER(S) NAME AND ADDRESS	FROM	TO DATES

2. Previous experience with radiation producing equipment:

TYPE(S) OF EQUIPMENT	EMPLOYER(S) NAME AND ADDRESS	DATES FROM	TO

3. Have you had an internal radiation exposure in amounts known (or suspected) to be above the permissible limits for occupational exposure? **YES NO UNKNOWN**

4. Has your occupational exposure to external radiation totaled more than 500 mrem (or 500 mrad) in any one year? **YES NO UNKNOWN**

The Boston College *Radiation Safety Manual* is available to me through my Principal Investigator and on line at www.bc.edu/ehs. I have received and read Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* and Regulatory Guide 8.29, *Instruction Concerning Risk from Occupation Radiation Exposure*. I have attended the radioactive materials safety course and was afforded the opportunity to ask questions addressing any concerns I have relating to potential occupation radiation exposure. If necessary, I give the Radiation Safety Officer permission to request my radiation exposure history from previous employers. I agree to comply with 1) all applicable Boston College rules and regulations governing the safe use of radioactive materials and 2) the conditions of approval listed on my project authorization, approved by the Boston College Radiation Safety Committee.

____ ____________

Signature Date

Radiation Safety Program Worker Registration Form, cont'd

SECTION III TO BE COMPLETED BY THE RADIATION SAFETY OFFICER

Interviewed by: ____ Date: ____________

Type of Interview: Radioisotope:________ X-ray:_______ Accelerator: _______

Instruction Material Supplied: Manual: __________ Information Sheets: _______

Regulatory Guides 8.13 and 8.29: __________________________

Other: ____

Date Terminated: ______________ Date Reactivated: _______________________

________________ __________________________

________________ __________________________

________________ __________________________

Dosimetry: Yes___ No ___ Body_______Wrist_______Finger:______

Spare Badge #______ Reference #_______ Issue Date________

Termination Date__________

Other:______________________________

Bioassay: Yes:________ No:_________

Urinalysis:_________ Radionuclides: _____________________________

In vivo Measurements: Whole Body:_______ Thyroid:___________

APPENDIX N. Principal Investigator Application Form

BOSTON COLLEGE **Page 1 of 2**
Office of Environmental Health and Safety
St. Clement's Hall

New User/User Update (circle one) **Application Date** ____/____/____

Name _______________________________Dept. ______ Apprvd. Date ____/____/____

Office ________Building __________ Extension ________ Exp. Date ____/____/____

Home/Cell phone # ___________________________

Isotopes to be used in:

Room ________ Building __________ Lab Extension ___________

Room ________ Building __________ Lab Extension ___________

Isotopes Used:

Isotope	Energy	t ½	physical/chemical form	Qty/experiment (μCi)	Lab Limit (μCi)
^{3}H	β^- (0.02 MeV)	12.26 y	___________	_____	_____
^{14}C	β^- (0.16 MeV)	5,730 y	___________	_____	_____
^{32}P	β^- (1.7 MeV)	14.3 d	___________	_____	_____
^{35}S	β^- (0.16 MeV)	88 d	___________	_____	_____
Other	______________	_______	___________	_____	_____

Purpose and Nature of Use (Also cite specific operations that may affect contamination and/or exposure (e.g. grinding, evaporations, volatile compounds, *etc*. Attach additional sheets.):

Training:
Attach form: Worker Registration Form - Appendix M.

Monitoring Devices:

	Location In Lab	Other Location
___ Whole Body Dosimeter	◻	_______________
___ Ring Badges	◻	_______________
___ Geiger Counter	◻	_______________
___ Scintillation Counter	◻	_______________
___ Other________________	◻	_______________

Storage and Disposal Methods:
The radioisotope material will be stored and disposed of in the following manner (attach sheet if necessary):

Safety Procedures:
Describe safety procedures to be implemented while carrying out work with this (these) isotopes. Be specific for each isotope.

PI AUTHORIZATION
As principal investigator for research using the specified radioisotopes, I certify that I am familiar with the regulations for radioisotope use as specified in the BC Radiation Safety Manual and that a copy of this is available in my laboratory; also, that workers under my supervision have been provided with written guidelines for handling the specified isotopes.

____ Date ___/___/___
Principal Investigator

____ Date ___/___/___
RSO/ARSO Approval

Note: Permission to use radionuclides automatically expires after 5 years.

APPENDIX O. Request for Radiation Exposure Records

BOSTON COLLEGE
Radiation Safety Officer, EHS
St. Clements Hall
I. 140 Commonwealth Avenue
Chestnut Hill, MA 02467

Date: ________________________

To: ____________________________________

____

____

____

Re: Occupational Radiation Exposure Records

In accordance with the recommendations of the NCRP and in compliance with the revised Title 10 CFR, Part 20, and 105CMR120.265, this office compiles occupational radiation exposure histories for all personnel who have worked with sources of ionizing radiation.

Please forward the pertinent data for:

Name: _____________________________

Date of Birth:_________________________

Period of Exposure:____________________________

Department:__________________________________

This information should come from documented records in your files and should indicate the method of monitoring (film badge, bioassay, or other) and the total dose for the exposure period in mRem.

Thank you for your cooperation.

Sincerely,

Radiation Safety Officer

Authorization for the release of my radiation exposure history to Boston College is hereby given:

Signature:____ Date:_________________________

APPENDIX P. 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 Nuclear Regulatory Commission, (NRC) 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 Boston College is 5000 mrem (50 mSv).

The NRC requires that all employees and students[8] 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 at the Office of Environmental Health and Safety in St. Clement's Hall and at EHS Radiation Program.

All current research work at Boston College involves exposures substantially below the recommended NRC 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 events are extremely unlikely, informing 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. Boston College will so limit occupational radiation exposure of pregnant employees who request such an accommodation during their pregnancies. However, while the NRC 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 radiation workers 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-Boston College locations must inform the Radiation Safety Officer of those activities.

[8] For the purposes of our NRC License conditions, students who work with radioactive materials must have their exposures controlled as if they were an employee.

APPENDIX Q. Proper Segregation, Minimization and Disposal of Radioactive Wastes

The Office of Environmental Health and Safety's Radiation Safety Technician will collect and process for disposal the various forms of radioactive waste generated at Boston College, provided that the waste is properly segregated, packaged and identified according to the methods detailed in this Appendix.

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/radionuclide 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 working in conjunction with the Office of Environmental Health and Safety .

Failure to adhere to the segregation and disposal procedures outlined here may result in:

1. **Radioactive waste being returned to the laboratory of origin for repackaging, OR**
2. **Laboratory personnel repackaging the radioactive waste at the radioactive storeroom.**

Thank you for your assistance and cooperation in complying with the following RSC protocols for the proper segregation and disposal of radioactive wastes at Boston College. Please contact the Office of Environmental Health and Safety (617-552-0308) should you have any questions, comments, or concerns regarding these protocols.

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

B. **Intermediate-Lived Radionuclide Categories [>18 day - $\leq$ 90 day half-life]:**

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

C. **Short-Lived Radionuclidic Categories [$\leq$ 18day half-life]:**

1. ^{32}P, ^{123}I, ^{131}I, ^{64}Cu, ^{11}C, ^{115}Cd, ^{111}Ag
2. ^{24}Na, ^{99m}Tc, ^{42}K

IMPORTANT REMINDERS:

- Employ waste minimization techniques at all times.
- Only the RST can dispose of solid radioactive waste.
- 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 (>0.5ml) with solid waste.
- DO NOT discard liquid scintillation vials with radioactive solid waste.
- DO NOT discard lead or leaded materials in with radioactive waste. Request a special collection.
- DO NOT discard chemicals in radioactive waste containers.
- For Radioactive sharps, use a special, labeled sharps container.
- DO NOT use translucent or opaque bags to discard radioactive waste. Use clear bags only.
- DO NOT leave radioactive labels or tape on short-lived waste.
- DO NOT mix radionuclides except as noted above.
- Maintain a record of each radionuclide, activity (uCi or mCi), and date bag filled.
- Inform the RST prior to collection 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 Tables 2 and 3 of Appendix C of the Radiation Safety Manual and 360 CMR Sections 10.023-10.025 of the MWRA Sewer Discharge Regulations. Calculation of minimum diluent volume must be performed in accordance with the formulas given in Appendix C of the Manual. Sink disposal should be followed by repetitive flushing with water and can only be performed in the designated radioactive disposal sink in the laboratory. Sink disposal log sheets **must** be filled out for each sink discharge of radioactive material specifying the date, amount, activity, and the person responsible.

Inorganic, water soluble Liquid Scintillation fluids (LSF) may be disposed of down the sink as long as they meet the criteria outlined in Tables 2 and 3 of Appendix C of the Radiation Safety Manual and Sections 10.023-10.025 of the MWRA Sewer Discharge Regulations.

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 wastes with half-lives <18 days should be labeled and stored-for-decay in the BC Radioactive Waste Storage Facility. After 10 half-lives the waste will be disposed of as chemical hazardous waste. Combine the material with vermiculite or plaster of Paris and call the RST for a pick-up of full containers.

Long lived organic liquids should be avoided at all costs. It is often difficult and costly to dispose of 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 effluent will be treated as chemical hazardous waste. Monitor activity of effluent 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 the volatile nature of radionuclides.
- DO NOT use Organic Liquid Scintillation Fluids.

LIQUID SCINTILLATION VIAL SEGREGATION AND DISPOSAL

FILLED LIQUID SCINTILLATION VIALS (LSF)

The Radiation Safety Technician will collect filled or partially filled liquid scintillation vials containing RSC approved non-hazardous or biodegradable scintillation fluids provided the vials are sorted and packaged according to the methods below. Liquid Scintillation Vials containing 3H of 14C can be disposed of by incineration as hazardous waste as long as average concentrations per box are below background.

Segregate vials by radionuclide content. Acceptable categories per tray or bag are:

- ^{3}H and/or ^{14}C
- ^{32}P, ^{99m}Tc, ^{131}I
- ^{35}S, ^{33}P, ^{125}I
- Ensure that vial cap is tightly secured.
- Segregate
- Collect waste vials in clear plastic bags
- Assure the radiation waste log (see Appendix R) is properly filled out
- Radiation Safety Technician will collect waste, secure bags, apply tags to all waste, and bring them to one of the main radiation waste rooms.

II. IMPORTANT REMINDERS

- DO NOT discard other forms of radioactive waste (gloves, paper, syringes, etc.) with vials.
- DO NOT discard vials with other solid radioactive waste.
- DO NOT discard "hot" commercial stock vials with scintillation vials.
- DO NOT use radioactive material tape to seal boxes of scintillation vials.
- Maintain a record of the radionuclide(s) and activity (uCi) of each radionuclide placed in the scintillation waste box; be as accurate as possible.
- **REUSE/RECYCLE** scintillation vials whenever possible.

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, x-acto knife blades, sharp metal objects, Pasteur pipettes, capillary pipettes, and broken glass.

To avoid potential injury to yourselves and the Radiation Safety Technician, radioactive sharps are not to be combined with other solid radioactive waste. All radioactive sharps must be disposed of in commercially available sharps containers that have been labeled with radioactive material tape. These containers are to be used for radioactive 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 are 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 $< 140^{\circ}$F (60°C); 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.

Radionuclide users are strongly encouraged NOT to generate mixed waste at Boston College. Please contact the RSO to discuss alternatives to prevent generation of mixed waste. Also:

- 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.

APPENDIX R. Radioactive Waste Storage Log

Box ID:________________________ **Location:_______________________**

Lab Source	Date to Storage	GM Reading (mR/hr)	Isotope	Activity (mCi)	Initials

Container Sealed Date: ____________________ Total Activity (mCi): __________________

Final Survey and Disposal Data:

Date:__________________ Isotope:_________________ Location:______________________

Survey Meter – Model: ____________ SN:__________ Cal Date:________ Cal Due: ________

Probe – Model: __________________ SN: __________ Cal Date: _______ Cal Due: _________

Radiation Level Background (mR/hr): ____________ Container Surface (mR/hr): ___________

Individual Performing Disposal

Name/Title: ______________________________________ Date: ___________________

APPENDIX S. Authorization to Possess and Use Equipment that Produces Ionizing Radiation

Principal Investigator ____

Location of the equipment: Building______________________________Room_______

Description of equipment, including operating parameters (voltage, amperage), target materials, detector attachments and use.

Maximum kV:____________________

Maximum mA:___________________

Description of safety devices including enclosures, shutter beam ports, warning lights, interlocks, and shielding.

Description of routine uses of the x-ray equipment including the purpose of experiments and the users.

Radiation survey meter available in the lab:

Brand__________________
Model__________________
SN __________________ .

Attach a diagram of x-ray location and setup

General conditions of the authorization for possession and use of equipment that produces ionizing radiation:

- The proposed work will be performed in the manner described in the sections above.
- There will be no changes to the operating procedures without the prior approval of the Radiation Safety Officer (RSO). The RSO shall be notified in writing prior to a change in location or use of the equipment.
- The use of the equipment will conform to all the requirements outlined in the BC Radiation Safety Manual.
- All personnel will receive radiation safety training from the Radiation Safety Officer and hands-on-training from the project supervisor prior to the use of the equipment.

Project Supervisor

Signature

____Date____________

____

Print Name

Specific conditions required by the Radiation Safety Officer:

Approved by: ______________________Title:__________________Date:________

APPENDIX T. X-Ray Machine Annual Monitoring Record

Date Performed:________________________
Performed by:_________________________

Location of Unit (Building and Room #):_________________________________
Responsible Staff Member:____

Brand Name:____
Model (#):____
Serial #:____
Description (i.e. spectrometer, generator)________________________________
Year purchased or installed:____

Monitoring Information:

Radiation at 5 cm from surface of closed shutters:_______________mRem/hr.
(Must be less than 2.5 mRem (0.025 mSv) in 1 hour)

Radiation at 5 cm from generator cabinet:_______________mRem/hr.
(Must be less than 0.25 mRem (2.5 uSv) in 1 hour)

Radiation in surrounding area?___________________(mRem/hr)
Distance from generator:________________________(ft)

Background Readings:____________________(mRem/hr)

Meter used for Survey: ____________________________

Serial #: ____

Calibration due date: ______________________________

APPENDIX U: Radioactive Nuclide Inventory

Isotope:___________________________________**Laboratory:**__________________________

NAME	DATE	QTY REC'D (mCi)	QTY USED (mCi)	SINK DISPOSAL (mCi)	WASTE (mCi)	TOTAL REMAINING (mCi)

APPENDIX V. Radioactive Material Order/Report Form

NOTE: Orders for Radioactive Materials Cannot be Processed Unless this Form is Completed and Returned to the Radiation Safety Technician.

LAB: ______________________ BLDG. and RM#_____________________

NUCLIDE: _____________________ SUPPLIER:_____________________

LAB HOLDING LIMITS FOR THIS NUCLIDE:___________________ (mCi)

CURRENT HOLDINGS FOR THIS NUCLIDE: _____________________(mCi)

NOTE: BE SURE THIS AMOUNT AGREES WITH YOUR LAB LOG.

AMOUNT BEING ORDERED: ________________________________(mCi)

ORDERED BY: ______________________________DATE: _____/_____/_____
(PRINT NAME)

This form is to be forwarded to the Radiation Safety Officer eric.johnson.5@bc.edu, fax 2-2743.

APPENDIX W. Personal Surveys for Users of Radioactive Materials

Directions:

1) Hands and working areas should be surveyed after each use *or* at the end of each day of use of radioisotopes – whichever is first.
2) Wipe tests are required.
3) Wipes should be counted in an appropriate instrument.
4) Results must be recorded. Negative results may be indicated by:
    - "B" for Background
    - "ND" for None Detected
5) Any results above 2X Background must be addressed.
6) The permit holder must retain this form for records.

Date	Initials	Isotope Used	Meter Survey Results – Hands, Lab Coat (CPM)	Meter Survey Results – Work Area (CPM)	Wipe Test Results – Use LSC (CPM)	Action for Results 2X Background

APPENDIX X: Radiation Safety Inspection Worksheet

Principle Investigator:____

☐ Higgins ☐ Merkert ☐ Devlin ☐ Other:__________ Laboratory Room Number(s):______________________

Survey Date Date: ____/_____/_____

Indicate Isotope(s) used or stored in this room:	^{35}S	^{32}P	^{14}C	^{3}H	Other:_____	N/A
Are isotope inventory logs filled out?			Yes		No	N/A
Are isotope inventories within allowed limits?			Yes		No	N/A
Are isotopes secured?	Lab locked ☐	Freezer locked ☐	Lock box ☐		No	N/A
Are emergency contact #'s posted by telephone?			Yes		No	N/A
Are personal survey forms up to date?			Yes		No	N/A
Are warning signs properly posted?			Yes		No	N/A
Are emergency contact numbers posted by the phone?			Yes		No	N/A
Is waste segregated in proper waste receptacles?			Yes		No	N/A
Are sink disposal logs up to date?			Yes		No	N/A
Are waste disposal logs up to date?			Yes		No	N/A
Are safety procedures posted in the lab?			Yes		No	N/A
Are DPH "Notices to Employees" postings present?			Yes		No	N/A
Is there any indication of food in the room?			Yes		No	N/A
Does this room need a follow-up inspection?			Yes		No	N/A

Monitoring Results

Highest meter reading in room______________________________________

RP#	Reference Point	Wipe-test Results (dpm)
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________

Comments

Survey performed by____________________
Meter Used: Ludlum3-GM
Serial # ______________________________
Calibration due date____________________

Reviewed by__________________________________Title___________________Date___________