DARTMOUTH COLLEGE RADIATION SAFETY HANDBOOK

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Reviewed: January, 2016

1 ADMINISTRATIVE ORGANIZATION AND RESPONSIBILITIES

1.1 Radiation Safety Personnel

Radiation Safety Committee

For a current list of Radiation Safety Committee (RSC) members, contact Environmental Health & Safety.

Radiation Safety Staff

Radiation Safety Officer:	Katrina Morgan
Assistant Radiation Safety Officer:	Jason Angell
Assistant Radiation Safety Officer:	Corey Martin

Office

Environmental Health & Safety	37 Dewey Field Road, HB6216

Telephone Numbers

Environmental Health & Safety 646-1762

Radiological Emergency Telephone Numbers

Work Hours (8:00 A.M. - 4:00 P.M.):

Call: 603-646-1762

After Hours (4:00 P.M. - 8:00 A.M. Emergencies Only):

Call: 442-1058

Enter the phone number you can be reached at.
Remain near the phone until your call is returned

REMINDER:

Treat Injuries First!
If you require First Aid or Medical Assistance –

Call 911 !

1.2 Purpose

The policies and procedures contained in this handbook have been established and are supported by the administration of Dartmouth College for the following purposes:

- To protect the Dartmouth College community, the general public and the environment from potential radiation hazards associated with the use of ionizing and non-ionizing radiation in research procedures, research or diagnostic devices and equipment.

- To ensure compliance with applicable federal, state and local regulations;

- To ensure that all ionizing radiation levels are maintained As Low As Reasonably Achievable (ALARA);

What does ALARA[1] mean at Dartmouth?

Simply stated, ALARA ensures that all reasonable steps (training, experiment design and oversight) will be taken to provide the lowest possible potential exposure to ionizing and non-ionizing radiation.

Specifically:

- Radiation safety training is required for all employees using radionuclides, x-ray producing equipment and/or any device/equipment that produces ionizing radiation. Training will include the concept and implementation of ALARA and contamination control.

- Experiments must be designed to minimize, as much as practical, personnel exposure to ionizing and non-ionizing radiation. This includes using the least amount of radioactivity as possible and/or using a less hazardous radionuclide whenever possible.

- Radiation monitoring will be provided for any individuals who are likely to receive radiation exposures. Exposure reports are reviewed to ensure that no unnecessary exposure has occurred.

- Waste Minimization is a key concept that is incorporated in all EHS established waste management guidelines and procedures. All researchers are asked to find alternatives to the use of radionuclides if at all possible.

Dartmouth College ALARA *goals for restricted areas are: Dose rate survey results to be kept under 2m*R*/hour and contamination survey results to be kept under 220 dpm/100 cm.*[2]

[1] See also ALARA Program Policy

1.3 Radiation Safety Committee

Committee Organization and Function

A large number of radioactive sources, radio-labeled compounds and radiation producing devices are used in biomedical research and medical diagnosis. If not properly controlled, they can potentially represent a serious hazard to the researcher, the public and the environment. The possibility of harmful effects to the health of individual users and the general public make it imperative to control the use of these materials within the institution; therefore, to minimize exposures to radiation, the Radiation Safety Committee (RSC) has established a radiation safety program.

The Radiation Safety Committee is a standing committee that reports to the Provost of Dartmouth College.

It will consist of nine members: the Radiation Safety Officer (RSO), Assistant RSO, an administrator, faculty members (one of which will serve as chairperson), a lab technician and the Chair of the Irradiator Sub-Committee. The chairperson will be appointed by the Provost. The DHMC Chief Medical Physicist and the DHMC Radiation Safety Officer will serve as ex officio members. The faculty members must have training and experience with ionizing and/or non-ionizing radiation. The committee will formulate policies and procedures for Dartmouth College. The committee will meet a minimum of four times a year (at least once per quarter) with additional meetings as necessary. A quorum consists of five voting members being present at meetings. Written records document all activities of the committee (meetings, recommendations, etc.). Records are retained for at least five years.

Committee's Responsibilities

- Establishes policies and procedures for the use of radioactive material, laboratory inspections, area surveys, leak testing of sealed sources, radiation safety training, handling of radiological incidents, radioactive material purchases, radioactive waste disposal, and radiation monitoring.

- Provides overall guidance of the Radiation Safety Officer. This includes a periodic review of the Radiation Safety Program to ensure compliance with State of New Hampshire Radiological Health Section (NHRHS) rules and regulations.

- Establishes and maintains policies and guidelines for the authorization of Principal Investigators' use of ionizing radiation. Authorization for the use will be granted by the Radiation Safety Committee upon the recommendation of the Radiation Safety Officer, provided that: the location, facilities, and equipment are adequate for the use of radionuclides and the procedures involved; the entire operation has been

evaluated for safety; emergency procedures have been established; and the Principal Investigator is adequately trained to handle the radioactive materials or x-ray equipment.

- Establishes and maintains policies and guidelines for the authorization of Principal Investigator's use of equipment that produces certain types of non-ionizing radiation.

- Ensures the research community is in compliance with the Radiation Safety Program. In the event of non-compliance with the Radiation Safety Program and upon the recommendation of the Radiation Safety Officer, the committee will notify the Principal Investigator (PI) of non-compliance in writing indicating steps required to rectify the situation. If the PI still does not comply with the regulations, the RSO will be granted the authority to suspend all activities involving radionuclides/x-ray producing equipment in his/her laboratory. The PI must surrender all radionuclides to the Radiation Safety Office for storage. X-ray producing equipment will be locked down by the RSO. Upon request, the PI will be granted a hearing before the Radiation Safety Committee. The decision of the Radiation Safety Committee is final.

- Audits the Radiation Safety Program annually to determine that activities are conducted safely and in accordance with New Hampshire Radiological Health Section rules and regulations and any conditions of the Dartmouth College Radioactive Material Broad Scope license.

1.4 Radiation Safety Officer's Responsibilities

The Radiation Safety Officer (RSO) is charged with the implementation, maintenance, oversight, and periodic modification of the Radiation Safety Program. The RSO's duties and responsibilities also include radiological safety operations and ensure program compliance with State of New Hampshire, Nuclear Regulatory Commission (NRC), Department of Transportation (DOT) regulations and the conditions of the Dartmouth College Radioactive Materia license. In support of these requirements the RSO will:

- Ensure that licensed materials possessed by Dartmouth College are limited to the types and quantities of byproduct materials as listed on the license;

- Maintain documentation that demonstrates the doses to members of the public do not exceed the limits as specified in New Hampshire Rules for the Control of Radiation;

- Ensure security of radioactive materials;

- Post documents as required by New Hampshire Rules for the Control of Radiation;

- Ensure that licensed material is transported in accordance with applicable State of New Hampshire, NRC, and DOT requirements;

- Ensure that radiation exposures are "ALARA";

- Oversee all activities involving radioactive material, including monitor and survey of all areas in which radioactive material is used;

- Act as liaison with the State of New Hampshire, the NRC, and other regulatory authorities;

- Provide necessary information on all aspects of radiation protection to personnel at all levels of responsibility;

- Oversee proper delivery, receipt and radiation surveys for all shipments of radioactive material arriving at or leaving from the institution, as well as packaging and labeling all radioactive material leaving the institution;

- Determine the need for personnel monitoring; distribute and collect personnel radiation monitoring devices; evaluate bioassays, personnel radiation exposure records for trends and high exposures; notify individuals and their supervisors of radiation exposures that approach the threshold limits; and recommend appropriate remedial action;

- Conduct or arrange for training programs and instruct personnel in the proper procedures for handling radioactive material or ionizing x-ray equipment prior to

use; provide refresher training at periodic intervals and whenever there are changes in experimental procedures, equipment usage, regulations, etc;

- Supervise and coordinate the radioactive waste disposal program, including effluent monitoring and record-keeping on waste storage and disposal records;

- Oversee the storage of radioactive material not in current use, including waste;

- Perform or arrange for leak tests on sealed sources and for calibration of radiation survey instruments;

- Maintain inventory records of all radionuclides possessed under the license and their limits authorized by the license;

- Immediately mitigate any unsafe condition or suspend activity that is found to be a threat to public health and safety or property;

- Supervise decontamination and recovery operations;

- Maintain other records not specifically designated herein, for example, records of receipts, transfers, and surveys as required by the New Hampshire Rules for the Control of Radiation;

- Hold periodic meetings with, and provide reports to, the Radiation Safety Committee and senior administration;

- Ensure that all radiation workers are properly trained;

- Perform or arrange for periodic audits of the Radiation Safety Program to ensure that the licensee is complying with all applicable State of New Hampshire and the NRC regulations and the terms and conditions of the license. Implement the Radiation Safety Program to achieve occupational doses and doses to members of the public that are ALARA in accordance with the New Hampshire Rules for the Control of Radiation;

- Ensure that the results of audits, identification of deficiencies, and recommendations for change are documented (and maintained for at least 3 years) and provided to management for review; ensure that prompt action is taken to correct deficiencies;

- Ensure that any audit results and corrective actions are communicated to all personnel who use licensed material;

- Ensure that all incidents, accidents, and personnel exposure to radiation in excess of ALARA or regulated limits are investigated and, if necessary, report to the State of New Hampshire and other appropriate authorities within the required time limits;

- Maintain access to up-to-date copies of New Hampshire Rules for the Control of Radiation, NRC regulations, DOT regulations, the license, revised procedures, and ensure that the license is amended whenever there are changes in licensed activities, responsible individuals, or information or commitments.

The Assistant RSO (ARSO) and/or Radiation Staff will assist the RSO in implementing the policies of the Dartmouth College Radiation Safety Program under the direction of the RSO and the Chair of the Radiation Safety Committee. In the absence of the RSO, the Assistant RSO will perform all the duties and responsibilities of the RSO under the direction of the Chair of the RSC.

2 AUTHORIZATION FOR USE OF RADIOACTIVE MATERIALS

2.1 Principal Investigator's Responsibilities

Principal Investigators (P.I.s) are researchers whose training and experience qualify them to directly or indirectly oversee the usage of radioactive materials or ionizing x-ray equipment. The PI shall adhere to all procedural guidelines and requirements for program maintenance found in the Radiation Safety Program. The responsibilities of a Principal Investigator (P.I.) are as follows:

- File an application for the use of radioactive materials. Each application is to be re-authorized by the RSC every 3 years;

- Request authorization in writing from the Radiation Safety Officer for each new radionuclide to be used;

- Inform the Radiation Safety Officer of all the rooms in which radioactive material is stored, or handled, or where ionizing radiation emitting equipment is used;

- Inform the Radiation Safety Officer of all personnel who may be handling sources of ionizing radiation;

- Designate a specific "contact" person to be responsible for radioactive materials use in the lab, and for maintaining up-to-date inventory, waste and swipe test logs for that lab;

- Allow only those persons, e.g., staff, students and visiting scientists, who have received radiation safety training to handle sources of ionizing radiation. No one under the age of 18 is allowed to work in an area where radioactive material is used without the written permission from the RSO;

- Inform female employees under his/her supervision of their rights when they suspect pregnancy and to contact the Radiation Safety Officer should they decide to "declare" their pregnancy. The purpose of this notification is to evaluate controls that may be implemented to reduce radiation exposure to the unborn;

- Obtain approval from the Radiation Safety Officer before any ionizing radiation sources are transported off campus;

- Inform all employees using ionizing radiation of the established procedures for storage, use and disposal of the radioactive material;

- Keep adequate records (a log book) of the receipt, use and disposal of all radioactive materials and submit required Environmental Health & Safety Office reports. The log book serves as the in-lab record;

- Ensure that inventory and waste logs are as accurate as possible;

- Consult with the Radiation Safety Officer when changes in the existing use of radionuclides may result in an increase in radiation exposure;

- Require radiation workers under his/her supervision to wear personnel protective equipment and assigned radiation dosimetry badges (if required) during periods of possible external radiation exposure, and assigning a designated storage location for all dosimeters when they are not in use;

- Ensure required radiation safety postings are in place and maintained;

- Require all lab personnel under your supervision complete the required safety training as mandated by Environmental Health & Safety;

- Purchase and maintain a functional, calibrated, radiation survey instrument. All hand held instruments for the detection of higher energy beta and gamma emitters must be Ludlum Model 3 count-rate meters with a 44-9 "pancake probe". When handling low energy gamma emitters (e.g. ^{125}I) a Na Iodide scintillation probe (Ludlum Model 44-3) is required.

- Establish laboratory procedures to ensure that radiation sources are properly labeled and securely locked when not in use; each laboratory is secured against unauthorized access when unoccupied; radiation surveys and/or swipe tests are performed to establish that radiation levels and/or contamination levels are within permissible limits; "Time of use" surveys are conducted whenever radioactive material is used; swipe tests are performed in accordance with the schedule established by the Radiation Safety Officer.

- Ensure sources that have not been used within six months are properly removed for disposal and from the Dartmouth College inventory, in keeping with the established ALARA policy.

- Inform the Radiation Safety Officer when there is a spill of radioactive material;

- Contact the Radiation Safety Officer when radionuclides will not be used for a period of six months or more.

2.2 Radiation Worker's Responsibilities

Radiation Workers are individuals who are qualified to work with radioactive materials or with ionizing radiation producing equipment by completing the requirements for such work set by the Radiation Safety Committee. These radiation workers or equipment users will work under the direction of a P.I. The Radiological Worker shall adhere to all procedural guidelines and requirements for program maintenance found in the Radiation Safety Program. The responsibilities of a Radiation Worker are as follows:

- Keep exposures to ionizing radiation As Low As Reasonably Achievable (ALARA);
- Complete the required safety trainings as mandated by Environmental Health & Safety;
- Conduct a whole body survey after working with open-form radioactive materials or whenever contamination is suspected;
- Wear the proper personal protective equipment (PPE), e.g., lab coats and disposal gloves, when working with or handling radioactive materials. PPE should not be worn outside of controlled areas;
- Eating, drinking, smoking, chewing gum, or applying cosmetics in areas under radiological control is not permitted. No evidence of the aforementioned activities will be discarded into trash receptacles in controlled areas;
- Maintain good personal hygiene. Wash hands and wrists thoroughly before exiting an area under radiological control;
- Use double gloves when working with radioactive materials if there is an abrasion of the skin below the wrist;
- Survey the work area for radioactive contamination upon completion of work involving radioactive material ("Time of Use" survey). Contaminated areas must be decontaminated immediately;
- Put "Caution Radioactive Material" warning tags on radioactive samples, contaminated equipment and waste containers;
- Notify the RSO or the designee if there is a personnel contamination, internal exposure or a major spill involving radioactive materials;
- Report all findings during contamination surveys in units of radioactivity (e.g. Disintegrations Per Minute (DPM) or microcuries);
- Report all evidence of non-compliance to the RSO.

- Never work alone in the laboratory when using radioactive materials.

2.3 Radionuclide Authorization Criteria for a New Principal Investigator

A. All Principal Investigators (P.I.'s) who wish to be authorized for the use of radioactive materials must do so through Radiation Safety Committee via the Radiation Safety Officer. The following information must be submitted to the Radiation Safety Officer at least two weeks prior to the date of the next Radiation Safety Committee meeting:

   - A completed application for use of radioactive materials.
   - A current curriculum vitae for the PI;
   - A diagram of the laboratory indicating areas designated for radioactive material use including location of storage areas, freezers and refrigerators, workbenches, sinks and radioactive waste disposal containers;
   - A list of safety and monitoring equipment available, if applicable. All labs requiring radiation survey monitors must have a Ludlum Model 3 with a model 44-9 "pancake" probe. If using low energy gamma emitters (e.g. ^{125}I), a Model 44-3 Na Iodide detector is required.

B. Upon receipt of this information, the Radiation Safety Officer will arrange a time for inspection of the facilities. All the following must be in place prior to final approval:

   - The PI must have completed all laboratory safety training including radiation safety training and must provide documentation of previous radioactive material experience;

   - All lab personnel who will be working in a radioactive use lab must complete all Dartmouth College required lab safety training including radiation safety prior to full authorization.

   - All lab personnel must be enrolled in the radiation monitoring program unless this requirement is waived by the Radiation Safety Officer in accordance with the radiation safety program;

   - An area must be designated for storage of personnel dosimeters when not in use;

   - Laboratory space must be designated for radionuclide use only. This includes storage areas, freezers and refrigerators, workbenches, and radioactive waste disposal containers. Criteria for adequate facilities are described in Section 2.4 "*Criteria for Approval of Laboratories using Radionuclides*" of this Handbook;

- The lab must be posted with a "Caution Radioactive Materials" (CRM) Sign, current Form BRH-5 "Notice to Employees" and an EHS Essential Information poster. These signs must be posted where they are prominently observable;

- Volatile and/or aerosol generating operations must be done in a fume hood;

- Radionuclide receiving, waste disposal and swipe test logs must be established and maintained;

- Radiation detection equipment and adequate shielding must be available in the lab and appropriate for the radionuclides requested, as specified in Section 2.4 "Criteria for Approval of Laboratories using Radionuclides" of this Handbook;

- Radionuclide work involving animals must be approved by the Institutional Animal Care and Use Committee (IACUC), the Radiation Safety Officer, and the Radiation Safety Committee;

- Details must be provided for any procedures that are new or unusual to the Radiation Safety Officer.

C. Final approval is granted by the Radiation Safety Committee contingent upon the recommendations of the Radiation Safety Officer. The RSC will refuse authorization if it determines that the facilities are inadequate, personnel training or experience is lacking or operational and handling procedures are substandard. The RSC will record its review, approval or disapproval in the minutes of the RSC meeting regarding authorization of investigators for use of radionuclides.

D. Following approval, possession and use will be limited to the specified radionuclides, chemical forms, amounts, and location(s) of use as designated in the approval. Any changes to the materials, amounts or areas designated in the approval will require prior authorization by the Radiation Safety Committee following an application for amendment by the PI.

2.4 Criteria for Approval of Laboratories Using Radionuclides

Basic Criteria for All Radionuclide Use Laboratories:

- The work area must be posted with a Caution Radioactive Materials (CRM) sign, current form BRH-5 "Notice to Employees" and an Essential Information on Radiation Safety poster.

- Adequate bench space shall be designated and marked for radionuclide use. Work surfaces must be of impervious material that can be easily decontaminated and also include the yellow plastic trays provided by EHS.

- Adequate storage space designated and marked for radionuclides, this includes refrigerators and freezers. All storage equipment must have a secure lock.

- Adequate space designated and marked for radioactive waste storage. For liquids, secondary spill containment such as trays or tubs must be used.

- Adequate shielding must be available for use in order to maintain exposures ALARA. Operations and storage areas must be shielded so that exposure levels are maintained at less than 2 mR/hr. The shielding material and its thickness will depend on the radionuclides and activities used.

- The laboratory must be adequately ventilated.

- Volatile or aerosol-generating radionuclides must be used within a fume hood tested and certified annually for proper function and adequate airflow. The face velocity of the fume hood should average 100 lineal feet per minute (LFM air speed). The hood must be uncluttered and have adequate workspace.

- Flooring must be of impervious material that can easily be decontaminated.

- All additional criteria as listed in Section 2.3, "Criteria for Authorization of New Investigators" of this Handbook must be satisfied.

- All laboratories are required to conduct periodic surveys as detailed in Section 4.8, "Survey Procedure for Contamination" of this Handbook.

- Hand washing, eyewash and safety shower facilities must be readily available and properly functioning.

Criteria for Specific Groups of Radionuclides:

- For weak beta emitters (< 200 keV, e.g., ^{3}H, ^{14}C, ^{35}S), a liquid scintillation counter, swipes, vials, and scintillation fluid must be readily available.

- For Strong beta emitters (> 200 keV, e.g., ^{32}P):
  a) Shielding of at least 3/8" inch plexi-glass or equivalent material must be present in the laboratory and employed when amounts greater than 100 microcuries (μCi) are used. For amounts greater than 250 μCi, denser shielding may be required. Waste containers should be shielded with a minimum of 3/8" plexi-glass or equivalent material.
  b) The lab must have its own properly functioning and calibrated portable radiation detector (Ludlum 3 survey meter with appropriate probe).. A properly licensed service provider must calibrate all such instruments annually.
  c) All laboratory personnel must wear their assigned whole body radiation dosimeters (see Section 4.3, "Procedures for Radiation Monitors" of this Handbook) when working with ^{32}P.
  d) Personnel performing experiments involving greater than 200 microcuries may be required to additionally wear an extremity dosimeter (ring badge, see Section 4.3, "Procedures for Radiation Monitors" of this Handbook).

- For gamma or x-ray emitters (e.g., ^{51}Cr, ^{59}Fe, ^{125}I):
  a) Lead shielding must be used for storage of stocks, liquid and solid waste to reduce radiation levels to less than 2 mR/hr at the outside of the shielding.

  b) The laboratory must have its own properly functioning and calibrated Ludlum 3 survey meter equipped with a Model 44-3 low energy gamma ("LEG") scintillation probe.

  c) If using unbound ^{125}I or ^{131}I, these experiments must be performed in the radioiodination laboratory (see section 4.6 and 4.7 of this Handbook).

- For sealed sources (e.g., ^{125}I seeds and other radioactive implants):
  a) Sources must be properly shielded and kept in a secure location.

  b) Sink and floor drains must have a fine mesh catch basket to prevent loss of sources into the drainage system.

  c) Solid waste containers must be transparent to gamma radiation to permit effective detection of sources in case of a suspected misplacement or loss.

  d) Sources with an activity greater than 100 microcuries must be tested for leakage by the Radiation Safety Officer at least every six months, and immediately if leakage of radioactive material is suspected. Leaking sources (> 0.005 μCi) must be removed from service and contained.

  e) A "Caution Radioactive Material" sign must be visibly posted in the entryway, so that a person entering the RAM area will see the posting.

  f) The laboratory must have its own properly functioning and calibrated Ludlum 3 survey meter with appropriate probes.

2.5 Criteria for Changes in Radionuclide Usage

Any anticipated changes in radionuclide, chemical form, amount or location of radionuclide use by an Established PI from those currently authorized by the Radiation Safety Committee will require temporary approval by the Radiation Safety Officer, with the Radiation Safety Committee having final approval decided at the next quarterly meeting. The criteria for changes in radionuclide use are as follows:

- Changes in the *location* of radionuclide use will require final authorization by the Radiation Safety Committee following inspection of the new laboratory space and a recommendation by the RSO;

- Authorization of additional radionuclides or changes in the authorized chemical form or maximum amount of a specific radionuclide will require approval of the Radiation Safety Committee. An application for the use of radioactive materials must be submitted to Radiation Safety Officer and include the following information:
  a) In the case of an amended activity limit or chemical form for a currently approved radionuclide, give a justification for the needed change.
  b) In the case of adding a new radionuclide, provide evidence that the PI is thoroughly familiar with the radiological properties of the new radionuclide and its safety requirements, give a justification for its need, and provide a brief description of the type of experiments to be performed. If the new radionuclide has special requirements, e.g. shielding and/or monitoring equipment, the RSO must inspect and approve the facilities prior to authorization by the Committee.

- No temporary or "ad hoc" arrangements will be permitted without the RSO approval in consultation with the RSC chair.

2.6 Criteria for Temporary Authorization of Established Principal Investigators

Since the Radiation Safety Committee meets quarterly, the Radiation Safety Officer has the authority to grant temporary authorization if the PI meets certain criteria. Temporary approval by the Radiation Safety Officer may not be used as a mechanism to allow new investigators to begin working with radionuclides. Temporary approval can only be given to currently approved investigators and only under restricted circumstances. A written request for the specific radionuclide must be submitted to the Radiation Safety Officer. The criteria for temporary radioactive material use authorization by an established Principal Investigator are as follows:

- The PI is currently authorized to use radionuclides and has an adequately equipped research laboratory;

- The PI is fully informed regarding the radiological characteristics of the sources and has adequate facilities and equipment available;

- Authorization is for only ***one*** additional radionuclide;

- The amount temporarily authorized for must not exceed 5 mCi during the 90-day period;

- The temporary authorization is valid 90 days or until the next meeting of the Radiation Safety Committee. After 90 days, the PI must determine whether or not to continue use of this radionuclide and submit a letter to the Radiation Safety Committee Chairperson requesting final approval for the use of this radionuclide;

- The Radiation Safety Officer may impose further conditions as appropriate.

3 EMERGENCY PROCEDURES

Each laboratory or area where radioactive material is used or stored must establish protocols for use or storage of radioactive materials to prevent or reduce the likelihood of spills and/or contamination to the extent practicable. Within these protocols, specific instructions are to be provided to Radiation Workers regarding the safe completion of those protocols to eliminate or reduce the potential for a minor or major spill or contamination. Below are listed some general instructions that should be applied at all times when working with radioactive materials.

Guidelines for the Safe Use of Radioactive Materials

- Wear a fully buttoned laboratory coat or other protective clothing at all times in areas where radioactive materials are used;
- Wear disposable gloves at all times when handling radioactive materials or handling items with radioactive material warning labels; in addition, wear safety glasses when handling high energy beta emitters;
- Monitor hands, shoes, and clothing for contamination after each procedure or before leaving the area;
- No eating, drinking, smoking or applying cosmetics in any area where radioactive material is stored or used;
- No storing food, drink or personal effects in areas where radioactive material is stored or used;
- Wear assigned personnel monitoring badges, if required, at all times while in areas where radioactive materials are used or stored;
- Never work alone in the laboratory;
- Dispose of radioactive waste only in designated, labeled, and properly shielded receptacles;
- No pipetting by mouth;
- Store radioactive solutions in clearly labeled containers;
- Secure radioactive material when it is not under the constant surveillance and immediate control of the user(s).

Emergency Procedures for Handling Spills

Prior to beginning ANY experiment that includes radioactive material, all personnel involved with that experiment shall be familiar with the emergency response plan for the lab. Emergency phone numbers for Radiation Safety staff shall be posted conspicuously in areas of use, so that they are readily available to workers in case of emergencies.

Minor Spills of Radioactive Liquids and Solids

The SWIMSS acronym is used to aid in the actions for spill response:

(S)top. Halt current actions and evaluate situation.
(W)arn. Notify pertinent personnel, such as Co-Workers, EHS, 911, etc.
(I)solate. Take immediate actions to stop further spilling of the material if possible and reasonable.
(M)inimize. Minimize your exposure using time, distance, and shielding.
(S)urvey. After performing clean up procedures, survey the area for detectable contamination.
(S)tandfast. Stand by at a safe location and await further assistance.

Instructions to Radiation Workers:

- Notify persons in the area that a spill has occurred.
- Prevent the spread of contamination by covering the spill with absorbent paper. (Paper should be dampened if solids are spilled).
- Clean up the spill, wearing disposable gloves and using absorbent paper.
- Carefully fold the absorbent paper with the clean side out and place it in a plastic bag for transfer to a radioactive waste container. Put contaminated gloves and any other contaminated disposable material in the bag.
- Survey the area with an appropriate low-range radiation detector survey meter or other appropriate technique. Check the area around the spill for contamination. Also check hands, clothing and shoes for contamination.
- Promptly report the incident to the Radiation Safety Officer (RSO).
- Allow no one to return to work in the area unless approved by the RSO.
- Be available to the RSO/Radiation Safety staff for further inquiry (i.e., investigation of root cause, provide requested bioassay samples).

Reminders to Principal Investigators:

- Follow up on the decontamination activities and documentation of results.

- As appropriate, determine the cause and take corrective action as needed; consider bioassays if radioactive material may have been ingested, inhaled, injected and/or absorbed through the skin.

In the Event of a Major Spill of Liquids and Solids

Major spills are defined as any accident involving radioactive materials resulting in one or more of the following situations:

- Radioactive material **greater than or equal to one millicurie** is involved;

- Radioactive liquids **greater than one liter** are involved;

- Any personal contamination;

- Any contamination in unrestricted areas;

- Multiple findings of contamination within a restricted area.

Instructions to Radiation Workers:

- Clear the area. If appropriate, survey all persons not involved in the spill and vacate the room.

- Prevent the spread of contamination by covering the spill with absorbent paper (paper should be dampened if solids are spilled), but do not attempt to clean it up. To prevent the spread of contamination, limit the movement of all personnel who may be contaminated.

- Shield the source only if it can be done without further contamination or significant increase in radiation exposure.

- Close the room and lock or otherwise secure the area to prevent entry. Post the room with a sign to warn anyone trying to enter that a spill of radioactive material has occurred.

- Notify the Radiation Safety Officer (RSO) immediately.

- Survey all personnel who could possibly have been contaminated. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and then wash with a mild soap.

- Allow no one to return to work in the area unless approved by the RSO.

- Cooperate with RSO/Radiation Safety staff (e.g., investigation of root cause, provide requested bioassay samples).

- Follow the instructions of the RSO/Radiation Safety staff (e.g., decontamination techniques, surveys, provide bioassay samples, submit requested documentation).

Reminders to Principal Investigators:

- Confirm the decontamination of personnel. If decontamination of personnel was not fully successful confer with the RSO for additional strategies that may reduce contamination levels. For instance, when absorption of radioactive material through intact skin has occurred and continued washing of the area has proven ineffective; consider inducing perspiration by covering the area with plastic. Then wash the affected area again to remove any contamination that was released by the perspiration.

- Supervise the decontamination activities and document the results. Documentation should include location of surveys and decontamination results.

- Determine the cause and take corrective action; consider the need for bioassays if radioactive material may have been ingested, inhaled, injected and/or absorbed through the skin.

4 POLICIES FOR USE OF RADIOACTIVE MATERIALS

4.1 Radioactive Material Purchasing Procedure

The procedure for purchasing radionuclides is as follows:

- The purchase of radioactive materials is controlled by the Radioisotope Inventory Management System sponsored by BIORAFT which can be found at: https://dartmouth.bioraft.com.

- The system has been designed to allow the approval of your radioisotope order such that you will not exceed your lab limit for a specific radioisotope or place an order for a radioisotope your lab is not authorized to use. It gives you permission for the order and gives you the specific "R" acquisition number. This "R" number becomes the tracking number for the radioactive material from delivery to final disposal.

- To become authorized to use this system, you must complete all necessary training. Once training is complete, EHS can then "rad enable" users to access the system. The training requirements are: (1) Introduction to Lab Safety training-*web-based*: one time only, (2) Radiation Safety training-*web-based*: annually, (3) Hazardous Waste Management training-*web-based*: every 3 years.

- Once you have become "rad enabled" and received your "R" acquisition number from Bioraft, you may place your order with the chosen supplier. Please make sure you use the "R" acquisition number when placing the order with an outside vendor and ensure the vendor places that "R" number on the shipping documents. (NOTE: The Bioraft system does NOT place your order, you must do this.)

- Radionuclides cannot be purchased using the College credit card or p-card. All purchases shall be processed through the e-procurement system.

- There are 2 approved receiving locations: All orders must be received at either --- *Site 1: Hanover* (includes all Hanover labs and any remote locations) or *Site 2: Lebanon* (includes all Borwell labs excluding Level 4 and all Rubin labs). Site 1 must be addressed to the Vail Loading Dock. Site 2 must be addressed to the Borwell Loading Dock. Packages will be checked in by EHS at each site in accordance with the procedures and delivered only if all the conditions listed in the procedure have been met.

- Radioactive packages are received and processed Monday through Friday during regular business hours, 8:00AM– 4:00 PM or by prior arrangement with EHS.

- Standing orders are not allowed.

- For Replacement orders: EHS must be notified when a shipment is unusable and when a replacement order will be delivered.

- Authorization and notification are mandatory for shipments which are acquired without a purchase order, e.g., compounds from other institutions, trial kits, etc. All such shipments must be addressed to the Environmental Health & Safety Office, in care of: (name of P.I.) and must clearly state that they contain radioactive materials. A tracking number will be assigned by EHS once the package has been received.

4.2 Radioactive Material Receiving Procedure

The procedure for receiving radionuclides is as follows:

- All orders will be received at *Site 1- Hanover Vail loading dock* or *Site 2 - Lebanon Borwell loading dock*. The Environmental Health & Safety Office will receive all orders and then deliver them if all the conditions listed in the purchasing procedure have been met.

- The EHS staff will inspect all packages for visible damage or leaks. If the package is damaged or leaking, it will be immediately set aside for further investigation by the RSO. All radioactive packages will be monitored and swipe tested for external contamination upon receipt. The package will be delivered to the laboratory by EHS staff. A signature is required from a lab authorized user to ensure the security and safe storage of the radionuclide package. You will receive a "Tracking Sheet" with the package. Each stock vial is given a "tracking number" by EHS so that the stock vial can be tracked from its receipt to its final disposal. If you receive a radioactive package without a "Tracking Sheet", contact EHS immediately.

Only individuals who have completed all of the required training will be permitted to unpack radioactive packages. The following steps are necessary for safe opening of these packages:

- Verify that the purchase orders agree with the outer package label;

- Wearing a fully buttoned lab coat and disposable gloves, place the package on a bench covered with absorbent paper or a yellow spill tray.

- Carefully open the package and remove the radionuclide. Use a Geiger counter to determine radiation levels.

- If a package or the internal container is damaged or leaking, contact EHS for assistance. The EHS staff will conduct swipe tests of the package material and the contents. The P.I. will be notified of the action and results.

- Monitor all packaging material. If not contaminated, then deface or obliterate any radioactive markings and dispose of packing material as non-radioactive waste. If contaminated, then treat it as radioactive waste and dispose accordingly.

- Verify that the innermost label agrees with the purchase order. Notify EHS of any discrepancies.

- Measure the radiation level of the innermost container using a suitable survey meter and document the results. If the radiation level is not consistent with the listed radionuclide, notify the Environmental Health & Safety Office immediately.

- Affix the tracking number to the vial before it is placed into storage. Record the receipt of the radionuclide in the laboratory receiving log. This includes date of receipt, tracking number, radionuclide, amount, lot number and final disposal date. Place the "Tracking Sheet" in the logbook behind the receiving log. When you dispose of the stock vial via the EHS waste pickup service, make sure the tracking sheet accompanies the vial. The date disposed to EHS must be registered on this tracking sheet. On receipt of this vial and tracking sheet, EHS will update your lab inventory using the Radioisotope Ordering and Inventory Management System sponsored by Bioraft.

4.3. External Radiation Monitoring Procedure

New Hampshire Radiological Health Section requires those individuals working with certain radioactive substances and/or ionizing radiation producing equipment to be monitored for occupational ionizing radiation exposure. Assigned personal monitors (dosimeters) must be worn at all times while working with ionizing radiation except when under diagnostic or therapeutic treatment. When not in use, they are to be stored in a location that has a low background radiation and is not subjected to excessive heat or moisture. A monitor is worn clipped on the belt, collar or pocket. Persons under the age of eighteen years are not permitted to work with radionuclides. The list of radiation workers and their exposure records will be maintained by the Environmental Health & Safety Office. Any reading greater than 50 mRem per quarter will be investigated by the Radiation Safety Officer.

All requests for monitoring must be done by completing a *Radiation Monitor Request Form.* The form is available from the Environmental Health & Safety Office or on the EHS Web site. The Radiation Safety Officer will evaluate the need for monitoring. The following guidelines will be used:

- Persons in laboratories not working with radionuclides will not be assigned radiation monitors.

- ^{3}H, ^{14}C and ^{35}S emit such weak radiation that external exposure monitoring is not feasible. Individuals working with only these radionuclides will not be issued dosimeters.

- Individuals working with ^{32}P used in amounts greater than 100 microcuries require quarterly whole body dosimeters, with ring badges to be required based on frequency of use and activity level per manipulation.

- Strong beta and gamma emitters such as ^{32}P and ^{51}Cr respectively in amounts greater than 100 microcuries require quarterly whole body dosimeters. At the present time, users of such radionuclides with activity greater than 200 microcuries per experiment are also required to wear ring badges.

- ^{125}I requires quarterly whole body dosimeters.

- All personnel working with X-ray equipment require quarterly radiation monitoring. A whole body dosimeter will be issued.

- All personnel working with neutron-emitting or photon-emitting sealed sources (with activities greater than 250 microcuries) require quarterly radiation monitoring. A quarterly dosimeter will be issued.

- All routine repeated elevated exposures (more than 50 mrem per quarter) will be investigated by the Radiation Safety Officer. At the discretion of the RSO, monitoring frequency may be altered from quarterly to monthly.

- A declared pregnant worker will receive both a whole body dosimeter and a fetal monitor for the duration of her pregnancy.

- Dosimeters will be sent to the appropriate departments and distributed by each department. When new monitors are issued to the departments, the old monitors must be returned promptly within at least five working days.

- Special situations that may require radiation exposure monitoring will be evaluated on a case-by-case basis.

- All badges must be returned to the Environmental Health & Safety Office within 5 working days after new badges are issued. Any radiation-monitoring device that cannot be returned within the five working days. Failure to meet this return time requirement may result in the suspension of radioactive materials use privileges for the both the individual and the associated P.I. Contact the RSO immediately if dosimeter returns will be delayed for any reason.

Radiation Exposure Must Be Kept As Low As Reasonably Achievable (ALARA)

4.4. Thyroid Monitoring Procedure

Special consideration must be given to unbound forms of iodine-125 (^{125}I). Individuals performing an iodination with unbound ^{125}I must adhere to the following monitoring requirements:

- Individuals performing radioiodination using 0.5 millicuries or more of iodine per experiment must be monitored for ^{125}I uptake[2]. Monitoring is done in two parts:

    a. A pre-count must be done within 24 hours prior to the iodination.

    b. A post-count must be done within 24 hours after iodination. If the experiment is performed on a Friday, then Monday morning would be the earliest time to do this.

- Whenever the thyroid burden at the time of measurement exceeds 0.12 microcuries of ^{125}I, or 0.02 microcuries of ^{131}I, (adhering to NRC Regulatory Guide 8.20: Application of Bioassays for ^{125}I and ^{131}I, Subparagraph 5: Action Points and Corresponding Actions), the following actions will be taken:

    a) An investigation of the operations involved, including air and laboratory surveys, should be carried out to determine the causes of exposure and to evaluate the potential for further exposures.

    b) If the investigation indicates that further work in the area might result in exposure of a worker to concentrations that would cause the limiting intakes established in Section 20.1202 of 10 CFR Part 20 (or corresponding State of New Hampshire limits) to be exceeded, the Radiation Safety Officer could take action to restrict the worker from further exposure until the source of exposure is discovered and corrected.

- At all times, the ALARA principle will be adhered to.

Pregnant Radiation Workers are restricted from performing radioiodinations.

[2] Contact EHS for the current procedure for thyroid monitoring.

4.5. Urine Monitoring Procedure

Individuals using more than 1 millicurie of ^{3}H, ^{35}S or ^{14}C (in unstable forms or where unstable forms may be produced) per experiment must notify the Radiation Safety Officer before the experiment is done. Urine monitoring is mandatory for experiments using 10 millicuries or greater. Bioassay monitoring may be requested at the discretion of the RSO for experiments of 1 millicurie or greater.

- Individuals must be monitored for ^{3}H, ^{35}S or ^{14}C accumulation by collection of urine specimens. Monitoring is done in two part:

  a) A pre-experiment urine sample must be collected as well as a post-experiment sample. The pre-experiment urine sample must be submitted to the Radiation Safety Office within 48 hours before the experiment is to begin.

  b) A post-experiment specimen must also be collected and submitted to the Radiation Safety Office within 72 hours (keeping in mind that tritiated water is eliminated with a 10-day biological half-life) after the experiment.

- Whenever the body burden at the time of urinanalysis exceeds 10 microcuries of ^{3}H per liter or 0.25 microcuries of ^{35}S or ^{14}C per liter (adhering to 10 CFR Part 20 or applicable State of New Hampshire limit), the following actions will be taken:

  a) An investigation of the operations involved, including air and laboratory surveys, should be carried out to determine the causes of exposure and to evaluate the potential for further exposures;

  b) If the investigation indicates that further work in the area might result in exposure of a worker to concentrations that would cause the limiting intakes established in Section 20.1202 of 10 CFR Part 20 (of applicable State of New Hampshire limits) to be exceeded, the Radiation Safety Officer could take action to restrict the worker from further exposure until the cause for the excess exposure is discovered and corrected.

- At all times, ALARA principles will be adhered to.

4.6. Radioiodination Policy

The radioiodination policy is as follows:

- All radioiodinations using greater than 0.5 millicuries of radioiodine are to be performed in the EHS Radionuclide Laboratory located in the Borwell Research Building, Room 582 West);

- An appointment to use the EHS Radionuclide Laboratory must be made through the Environmental Health & Safety Office prior to use and should be made for the estimated duration of the procedure. The EHS Radionuclide Laboratory is available for appointments Monday through Friday 8:00 AM to 4:30 PM;

- Anyone performing radioiodinations in the EHS Radionuclide Laboratory will be instructed in the use of the facility by the Radiation Safety Officer;

- A low-energy gamma survey meter must be on hand and remain "on" throughout the iodination procedure;

- Within 24 hours prior to iodination (greater than 0.5 millicuries), a thyroid survey must be performed. A second survey must also be performed within 24 to 72 hours after the iodination. Please contact EHS to arrange these surveys.

- All solid radioactive waste must be sealed in clear bags, with an attached, completed radioactive waste tag (please include the account number) and deposited in the waste pail. For liquid radioactive waste, place in a plastic carboy located in the fume hood and attach a completed radioactive waste tag. For stock vial disposal, leave a copy of the tracking sheet with the vial. E-mail Environmental Health & Safety that there is radioactive waste for pick-up;

- Upon completion of the iodination, the user is responsible for cleanup of the area. All equipment brought to the lab must be taken out by the user;

- Swipe tests are required after each radioiodination. These are to be done in accordance with the forms provided by EHS. Please follow the standard operating procedure for performing the required swipe testing. If the room has become contaminated, EHS will notify the user and he/she will be responsible for cleanup of the area. The laboratory will not be available for further use until swipe tests show counts of less than 220 dpm/100 square centimeters.

- A general cleanup will be performed as needed by the Environmental Health & Safety Office. A lead shield, clear plastic bags for solid waste and trays to work on will be provided. Users must provide any protective equipment needed for the experiment such as disposable gloves.

Standard Operating Procedure for Radionuclide Lab Swipe Tests:

- ✓ All users of the iodination lab are required to swipe test the area at the completion of each experiment. EHS will provide the necessary supplies;
- ✓ Wear lab coat, safety glasses radiation monitor and disposable gloves;
- ✓ Verify the locations to be swiped on the worksheet and map provided;
- ✓ Use the liquid scintillation vials;
- ✓ Using the test paper provided, swipe an area of 100 square centimeters (approximately a 4" x 4" area) at each identified location. Handle swipes in such a manner as to avoid cross-contaminating the swipe samples. Areas to be swiped are indicated on the iodination lab map provided by EHS.
- ✓ Place the test paper in the appropriate vial for counting. Secure caps on vials;
- ✓ Contact EHS when you have completed the swipe testing. EHS will count the vials and report the results to the user;
- ✓ If no contamination is found, the EHS Radionuclide Lab will be made available for the next user;
- ✓ If contamination is found (counts greater than 220 dpm), the user will be requested to clean the lab until counts are under 100 dpm. Other locations will also be swipe tested at this time to ensure contamination hasn't spread outside of the lab area;
- ✓ Please be aware that gross, serious contamination of the lab may result in a citation by the RSO. All personnel using the facility are to keep it clean and orderly. No equipment, materials or supplies are to be removed. Report all problems with this room to the RSO.

4.8. Contamination Survey Procedure

All areas where radionuclides are stored, used, and disposed must be surveyed and documented for contamination on a periodic basis, depending on the types of materials and use frequency. "Time of Use" surveys must be conducted after each use of radioactive materials. For low energy radionuclides, such a survey involves swipe testing. For higher energy radionuclides such as ^{32}P, a direct monitoring survey may be used. It is performed using a Geiger counter such as the Ludlum 3 with pancake probe. *Fixed contamination* is radioactive contamination that cannot be easily removed, such as material that has been absorbed onto an unsealed floor. *Removable contamination* is radioactive contamination that can be removed by washing or wiping. It is important to differentiate between removable and fixed contamination.

The general procedure for a *contamination* survey is outlined below:

- Wear a fully buttoned lab coat, safety glasses, dosimeter (if issued) and disposable gloves;

- Remove all radiation sources that could interfere with the survey;

- Identify the locations where radioactivity is used and/or stored and the equipment that is used for work involving radioactivity;

- Key these locations to the lab's floor diagram with letters or numbers;

- Check the survey meter for the following functions:

  a) Battery check. The indicator needle should be within the battery range as indicated on the dial. Meters must always be used in the audible mode for contamination surveys;

  b) Function check. Using an external standard, verify that the instrument works properly;

  c) Background check. Determine approximate cpm or mR/hr of the ambient environment using the 0.1 X scale in a low background area;

  d) Calibration. Check the date of the last calibration. This date should be affixed to the side of the instrument. Survey meters must be calibrated annually. Contact the RSO if your instrument requires calibration.

- Use a thin, window GM Counter such as the Ludlum model 3 with Type 44-9 pancake probe and sweep the area slowly approximately 1/2 inch above the surface. Do not touch or brush the thin membrane window;

- As a general rule, survey results greater than 220 dpm/100cm^2 or 0.2 mR/hr are considered suspect contamination. Clean with a decontamination solution and re-survey. Remember when conducted direct monitoring surveys with instruments calibrated to read in counts per minute (CPM) to convert such readings into units of radioactivity. Subtract background readings from the gross counts identified and divide the resulting Net CPM by the instrument efficiency for the radionuclide in question (Note: the efficiency can be found on the calibration sticker or certificate). This calculation will result in disintegrations per minute (DPM) which you can then compare to our contamination limit.

- If after cleaning counts are still present, perform a swipe test as described below:

  - Label appropriate number of scintillation vials to include a machine standard, background (a non-radioisotope area), and all areas of radioisotope work.

  - Use one-inch filter paper and swipe an area of 100 square centimeters (approximately 4" X 4" square area) at each identified location or piece of equipment. Handle wipes in such a manner such as to avoid cross-contaminating the wipe samples;

  - Place the swipes in scintillation vials for counting. For liquid scintillation counting, add approximately 4 milliliters of liquid scintillation cocktail into each vial. Secure the caps on vials;

  - Count in a suitable counter using a machine standard to calculate the efficiency of the instrument. Count for at least 1 minute;

  - Record results and any corrective action on the swipe test log sheet. (The values must be recorded as dpm.) This includes date of survey, room number, initials of person conducting the survey, type of counter with serial number, background counts and wipe results of all contaminated and re-cleaned areas.

Decontamination Procedure

Swipe tests are done to verify that removable radioactive contamination is kept below 220 dpm/100 square centimeters in controlled areas. Swipe tests must be kept below 2x background in dpm/100 square centimeters or less in uncontrolled areas.

- If swipe test results are greater than 220 dpm, the area should be cleaned with a decontamination solution and then resurveyed. If counts still remain high, the area is considered contaminated and must be posted as such. The Radiation Safety Officer must be notified to determine the corrective action. This may include abrasive cleaning, shielding or denying access to the contaminated areas.

- If swipe test results are less than 220 dpm, depending on the type of radioactive contamination, no additional corrective actions may be needed.

Controlled Areas vs Uncontrolled Areas

A *controlled area* at Dartmouth College includes any area in which radionuclide use is authorized. Access to these locations is restricted to authorized personnel. When labs are unoccupied (e.g., nights, weekends), they must be locked. Survey results should be below 220 dpm/100 square centimeters. If the value is greater than 220 dpm, consider the area or items to be contaminated. Clean up the contamination and repeat the swipe tests. (The Dartmouth College ALARA goals are that all rad work area surfaces should be below 220 dpm/100 square centimeters and the radiation levels should not exceed 0.2 mR/hour at 1 centimeter over the area.)

An *uncontrolled area* at Dartmouth College includes all areas that are not restricted to the public. All surfaces in these areas should be below 2x the background level in dpm/100 square centimeters. If the value is greater than 2x the background level in dpm, consider the area or items to be contaminated. Clean up the contamination and repeat the swipe tests. (The Dartmouth College ALARA goals are that all non-rad work area surfaces should be below 2x the background level in dpm/100 square centimeters and the radiation levels should not exceed 0.1 mR/hour at 1 centimeter over the area.)

4.9. Sealed Sources

- All radioactive sealed sources with activities above certain limits must be registered with the Radiation Safety Office.

- Sealed sources must be kept secured from unauthorized access when not in use.

- The area where sealed sources are used and stored must be posted with a **"Caution Radioactive Material"** sign, current **NHRHP Notice to Employees** and an **Essential Information on Radiation Safety** poster.

- All sealed sources are required to be leak tested within the timeframes designated in Dartmouth College Radioactive Materials Licenses 278R and 382R. (Please contact EHS for clarification of this process.)

4.10. X-ray Producing Equipment

X-rays are electromagnetic energy traveling as waves. They are the same as gamma rays except that gamma rays are emitted from the nucleus of an atom while x-rays originate in the atom's electron cloud. Analytical x-rays are produced by accelerating electrons from a cathode into an anode (target), within an x-ray tube. X-rays can be very penetrating. The voltage of the system indicates how penetrating the x-rays will be---the higher the voltage of the generator, the more penetrating the radiation. Just like gamma rays, x-rays interact with molecules in the body to produce ion pairs. To protect personnel from these penetrating rays, thick, dense material (e.g., lead, steel, etc.) is used as shielding.

Certain analytical systems, (e.g., x-ray diffraction units), have sufficient voltage to produce low energy (e.g., 1- 50 keV) or soft x-rays. The soft x-rays with energies from 1 to 20 keV are absorbed in the first few millimeters of the skin, although for extremities, some of this radiation may also be absorbed to the bone. Excessive exposure to this type of radiation often produces skin reddening at approximately 300 Rem (300,000 mRem) while severe skin burns can result from exposures above 500 rem. Because some types of analytical x-ray systems can produce exposure rates between 1000 and 1,000,000 mRem/hr, even short exposures to the beam are capable of producing damage. For that reason, the primary radiation beam must always be contained in a shield.

All x-ray producing equipment must be registered with EHS prior to purchasing. Contact EHS for *"X-ray Producing Equipment Management SOP" and the "X-ray Producing Equipment Handbook".*

4.11. Radionuclide Use in Animals

The New Hampshire Radiological Health Section regulates many activities involving the use of radionuclides. A policy for the use of radionuclides in animals at Dartmouth has been developed and approved by both the Radiation Safety Committee (RSC) and the Institutional Animal Care and Use Committee (IACUC). The following procedures are designed to fulfill part of Dartmouth College's radioactive materials license requirements, to ensure proper use of animals in these experiments and to promote the safety of personnel involved in the handling and care of these animals. Investigators are encouraged to contact the Environmental Health and Safety Office (EHS) or the Center for Comparative Medicine and Research (CCMR) with any questions or for assistance in obtaining the required approval..

The procedure for Radionuclide Use in Animals is outlined below:

To obtain approval for an experiment involving the use of radionuclides in animals at Dartmouth, an animal subjects review form must be submitted to the Center for Comparative Medicine and Research (CCMR). This form contains not only the necessary information on the use of animals for experimentation but also the additional information requested regarding the radioactive materials. The proposal will be reviewed by both a subcommittee of the IACUC and by the RSC. Approval of the proposal from both the IACUC and the RSC must be obtained prior to the start of work.

4.12. Transportation of Radioactive Materials

Hazardous Materials Regulations as they apply to radioactive materials are described in 49 CFR 173, Subpart 1. The Hazardous Materials Regulations are designed to ensure that the general public is not at risk from hazardous cargoes being transported on the public transportation system. Material packaging requirements are to ensure (1) packaging material is of sufficient strength and quality to withstand normal transportation conditions; and (2) the selected packaging material must be compatible with the material to be shipped and must be suitable to the level of risk presented by the material.

The Department of Transportation (DOT) defines radioactive material as material having a specific activity greater than 0.002 microcuries/gram. Once identified as radioactive, its description and shipping name need to be identified to properly label the package for shipping and transporting. Therefore any radioactive material that requires transportation from off-campus locations must follow specific DOT guidelines. For the purposes of this procedure, *off-Campus* refers to any space which is not owned, rented or leased by Dartmouth College. If radioactive material is to be transported (between Borwell /DRTC and DC) or shipped via a commercial carrier, the Radiation Safety Office must be notified in advance. No shipment or transport of radioactive material will be allowed without written the approval from the Radiation Safety Officer.

The goal of hazard communication (e.g., shipping papers, labeling, placarding) is to prevent problems at the scene when responding to a transportation accident by providing hazard identification information to shippers, carriers and emergency responders. To this end, the Radiation Safety Officer will assist you in preparing shipping papers, marking, labeling, and emergency response information.

The procedure for off-campus transportation of radionuclides is as follows:

- Notify the RSO that you have radioactive material you wish to ship off-campus.

- Package Identification--The types of packaging which are required for transporting radioactive material at or from Dartmouth College should usually be one of two types: (1) strong, tight packages for transporting limited quantities of radioactive materials; or (2) Type A packages for transporting material in amounts exceeding limited quantities. The package must be certified as being acceptable for transportation by the Radiation Safety Officer.

- Radioactive materials that are to be shipped as limited quantity must meet the following requirements:

    a) The material must be packaged in a strong, tight package that will not leak any of the radioactive material under conditions incidental to normal transport. The requirements for shipping containers of radioactive materials should be adequate to assure that in the event of an accident, undamaged packages will be safe.

b) The radiation level at any point on the external surface of the package must not exceed 0.5 mR/hour;

c) Removable contamination on the external surface of the package must not exceed 220 dpm/100 square centimeters;

d) The outside of the inner packaging, or if there is no inner packaging, the outside of the package itself bears the marking Radioactive;

e) If the radioactive material is to be shipped on dry ice via air, the package must be marked (on one side) with the DOT diamond label for miscellaneous dangerous goods;

4.13. Radionuclide Use by Visitors (non-Dartmouth College employees)

It is the policy of Dartmouth College to help ensure the safety of all faculty, staff, students, visitors and guests. In the context of our radiation safety program, a visitor is defined as someone who is not a Dartmouth employee or student who is temporarily working on Dartmouth College property to conduct research which may involve the use of radioactive materials.

The procedures for enrolling a visitor in the Dartmouth College Radiation Safety Program are outlined below:

- The visitor must be sponsored by and work under the supervision of a currently authorized Principal Investigator. It is the responsibility of the sponsoring P.I. to provide the documentation described below to the Radiation Safety Officer within four weeks prior to the visitor's arrival so that the visitor can be approved, trained and be provided with a personal dosimeter, if required. If the information is not provided in sufficient time, the visitor will be prohibited from working with radioactive materials. It is the responsibility of the P.I. to ensure the visitor's safety and compliance with all relevant Dartmouth College policies.

- The P.I., in conjunction with the visitor and the visitor's institution (if applicable), will provide a cover letter briefly describing the visitor's role, duration of visit and the anticipated type, amount, and expected exposure to radioactive materials; and will provide documentation of the visitor's previous training and experience with radioactive materials and an application for a personal dosimeter where appropriate.

- The visitor must complete all EHS mandated training which includes Lab Safety Training (classroom), Radiation Safety Training (classroom), Hazardous Waste Management (web-based) and refresher Radiation Safety (web-based). (A sponsored DND account must be established before the visitor can complete the web-based trainings). Once training is complete, a dosimeter will be issued, if required.

- The visitor must be familiar with and adhere to the radiation safety policies of Dartmouth College (including this visitor policy) at all times while working with radioactive materials on Dartmouth property.

- At the conclusion of the visit, the P.I. must notify the RSO of the termination of the visit and must turn in the visitor's personal dosimeter if issued by Dartmouth College.

- Failure of the P.I. to properly notify the Radiation Safety Officer of visitors or to adhere to these policies will be considered a serious violation of Radiation Safety Policy and will result in review by the RSC and subsequent action as described in the Compliance Policy (section 4.18).

4.14. Radioactive Waste Policy

Minimization of waste is the most effective way in dealing with costs and liabilities of radioactive waste disposal. Apply all available methods to limit the waste to a minimum.

Waste minimization includes:

- Purchase only the amount of radioactive materials necessary to complete the experiments;
- Use short-lived radionuclides rather than long-lived radionuclides, if possible;
- Avoid unnecessary contamination of lab items and equipment;
- Do not mix short-lived with the long-lived waste. Otherwise all the waste will be treated as a long-lived waste;
- Distinguish between contaminated and non-contaminated items for proper segregation of waste.

General instructions for radioactive waste management:

- All waste must be in an properly labeled EHS provided container or a clear plastic bag;
- Avoid mixing radioactive waste with hazardous chemicals;
- Segregate liquid scintillation vials from other radioactive solid waste.
- Needles and syringes contaminated with radioactivity must be placed in a red needle (SHARPS) container. Label the container with a "Radioactive" warning sticker.
- Disposal of lead pigs: Remove or obliterate all radioactive labels before calling EHS for a pick-up.
- Drain disposal of radioactive liquid waste is not allowed without prior EHS approval. Liquid waste must be placed in a 1-gallon or smaller plastic container.
- All waste bags and liquid containers must have the completed EHS Radioactive Waste Tag attached to them prior to EHS waste pick-up.
- Use the electronic radioactive waste pick-up form found on the Radioisotope Inventory Management System sponsored by Bioraft to request waste pick-ups.

For more detailed information on radioactive waste procedures, please refer to the "*Hazardous Waste Guide*" found on the EHS web-site.

4.15. Laboratory Inspections

Lab inspections are designed to evaluate the use of radioactive materials and to ensure the laboratory is in compliance with existing regulations and accepted laboratory practice. It determines if radioactive materials are being received, used and stored properly. It also evaluates any potential problem of misusing and mishandling of radioactive materials and waste. If there are violations cited during an inspection, a researcher must take corrective action promptly. Inspections are performed by the Radiation Safety Officer, or designee. After the inspection, each laboratory will receive a written report describing inspection results and any corrective actions that need to be followed.

The following are some of the requirements that are checked during an inspection:

- Posting of the current "Notice to Employees", Radioactive Material symbol and emergency procedures;
- Laboratory coats, radiation badges and disposable gloves are worn when working with radioactive materials;
- Shielding is available and is made of the proper material and adequate thickness;
- Waste areas are designated, labeled and properly shielded;
- Radioactive material is properly secured.
- Records of inventory/usage/waste are up to date;
- Each laboratory has a working and calibrated survey instrument;
- No indication of food or drinks being consumed in laboratories;
- No storage of food or beverage in refrigerators where radioactive materials are stored;
- All laboratory areas are reasonably free from radioactive contamination.

4.16. Compliance Policy

Dartmouth College is committed to ensuring compliance with all relevant Federal, State and local regulations regarding the safe use of ionizing radiation through its Radiation Safety Program. In order to do this effectively, the RSC has developed a compliance policy that describes possible violations that can result in non-compliance with these regulations. Chronic non-compliance with any regulation can potentially jeopardize the radioactive materials license for Dartmouth College. The goal of the Radiation Safety Program is to ensure that all personnel are in compliance; in addition, this policy also describes the actions that will be taken by the Radiation Safety Officer and/or the RSC in response to violations by individuals and laboratories should they occur. These offenses have been divided into three categories: Record-keeping offenses, Major Offenses and Radioiodination Lab Policy Offenses. It is important for all personnel to understand the consequences of such non-compliance and to avoid such violations to the best of their ability. It is the responsibility of the Principal Investigator to ensure that all personnel under his or her supervision are familiar with these consequences and to be in compliance with all Radiation Safety Policies.

Record-Keeping Offenses

The following is a non-exclusive list of record-keeping offenses:

- Unacceptable practices for maintenance of individual lab logbooks: updated receipt and swipe test logs.
- Non-compliance with the radionuclide purchasing and receiving procedures.
- Non-compliance with established monthly or "time of use" survey documentation requirements.
- Improper or inadequate labeling of waste.
- Late return of dosimetry to the Environmental Health & Office or chronic loss of dosimeters.

These and similar offenses will result in the following:

First Violation: Memorandum from the RSO to the Principal Investigator (and offender of policy if different) with a copy to the Chair of RSC and to the EHS files.

Second Violation (within 1 year of first violation): Memorandum from the RSO to the Principal Investigator (and offender of policy, if different) with reference to the earlier Memorandum with a copy to the Chair of RSC and to the EHS files.

Third Violation (within 1 year of second violation): Memorandum from the RSC to the Principal Investigator stating the recurring problem and dates by which the lab must come into compliance. If non-compliance continues, the Principal Investigator will be requested by the RSO or the Chair to appear before the RSC to explain the non-compliance problem.

The RSC may then take whatever other action it deems necessary to bring the laboratory into compliance with current policies.

Major Offenses.
The following is a non-exclusive list of major offenses against the Radiation Safety Policy. The RSO and/or RSC may deem other violations against current policies, not listed here, as also constituting a major offense leading to the actions described below:

- Evidence of food and/or drink in the laboratories;
- Lack of safe work practices with disregard for safety of others in the laboratory;
- Excessive accumulation of radioactive waste in the laboratory;
- Lack of labeling of radioactive materials and waste in the laboratory;
- Not reporting spills to the Environmental Health & Office immediately;
- Not performing radiation and contamination surveys;
- Loss of radioactive materials;
- Inadequate security of radionuclides;
- Uncontrolled access to laboratories that use and store radioactive materials above certain activities when no one is present;
- Gross contamination of work areas;
- Removable contamination in excess of established limits;
- Non-conforming waste presented for disposal.

These and similar offenses will result in the following:

First Violation: Memorandum from the RSO to the Principal Investigator (and offender of policy if different), with a copy to the Chair of RSC and to the EHS files.

Second Violation (within 1 year of first violation): Memorandum from the RSC to the Principal Investigator (and offender of policy, if different) stating the problem and dates by which the lab must come into compliance. If non-compliance continues, the RSO may immediately revoke the radioactive material use authorization and remove all radionuclides from the laboratory. The Principal Investigator must appear before the RSC to justify the non-compliance and propose a long-term solution for the laboratory's future compliance. The Principal Investigator must re-apply to the RSC for radioactive material use authorization. The RSC may take whatever actions it deems necessary to ensure the laboratory's

compliance, to include but imposing additional restrictions and/or denial of radioactive material use at Dartmouth College.

Radioiodination Laboratory Policy Offenses

The following is a non-exclusive list:

- Thyroid monitoring not performed;
- Lack of swipe testing and/or clean-up of the lab;
- Serious contamination of laboratory.

These and similar offenses will result in the following:

First Violation: Memorandum from the RSO to the Principal Investigator (and offender of policy if different) with a copy to the Chair of RSC and to the EHS files.

Second Violation: The user will be prohibited from using the Iodination Lab.

4.17. Exposure to Radiation During Pregnancy Policy

Research has shown that a fetus is more sensitive to the damaging effects of radiation exposure, particularly during the first trimester of the pregnancy. In recognition of this increased radiation sensitivity, a more restrictive dose limit has been established for the embryo/fetus of a declared pregnant radiation worker. Guidance in conformance with the revised 10 CFR Part 20 is being developed as a proposed Revision 3 to Regulatory Guide 8.13. It has been published as Draft Regulatory Guide DG-8014 "Instruction Concerning Prenatal Radiation Exposure". Currently NRC regulations require that the radiation dose to the fetus of an occupationally exposed pregnant worker be held to 0.5 rem (5 mSv) or less during pregnancy. (see also Declared Pregnant Radiation Worker Policy Statement)

Radiation protection regulations allow a pregnant radiation worker to decide whether she wants to formally declare her pregnancy to her employer, thereby taking advantage of the special dose limits provided to protect the developing embryo/fetus. If an occupationally exposed woman declares her pregnancy to the Radiation Safety Officer then she is subject to the more restrictive dose limits for the embryo/fetus during the remainder of the pregnancy which is controlled by restricting the exposure to the declared pregnant woman. Restricting the woman's occupational exposure, if she declares her pregnancy, raises questions about individual privacy rights, equal employment opportunities and possible loss of income. Because of these concerns, the declaration of pregnancy by a woman radiation worker is voluntary. Conversely, the woman can also withdraw her declaration of pregnancy by notifying the Radiation Safety Officer.

When a worker has made the decision to formally declare her pregnancy, she may complete "Form Letter for Declaring Pregnancy" or she may submit her own letter. Once this form has been received, the Radiation Safety Officer will contact the worker to discuss her use of radioactive materials or work with x-ray producing equipment in the lab, her previous exposure history and any other relevant information. At this time, the worker is offered the opportunity to enroll in the pregnancy surveillance program that allows for the closer monitoring of radiation exposure to the fetus during the entire pregnancy.

FORM LETTER FOR DECLARING PREGNANCY

This form is provided for your convenience. To make your declaration of pregnancy, you may fill in the blanks of this form letter and give it to your employer/Environmental Health & Safety or you may write your own letter.

DECLARATION OF PREGNANCY

TO: _____
(Name of Supervisor or Radiation Safety Officer)

In accordance with the NRC's regulations at 10 CFR 20.1208, "Dose to an Embryo/Fetus," I am declaring that I am pregnant. I believe I became pregnant in: (only month and year need be provided).

I understand the occupational radiation dose to my embryo/fetus during my entire pregnancy will not be allowed to exceed 0.5 rem (5 millisievert) (unless that dose has already been exceeded between the time of conception and submitting this letter). I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

I will promptly inform the Dartmouth College Radiation Safety Officer in writing when my pregnancy has ended.

_____
(Your signature)

_____
(Your name -printed)

_____
(Date)

4.18. Shared Space Policy

Ideally, each principal investigator who is authorized for radionuclide use should work in a separate laboratory and keep separate logs of radionuclide receipt, storage, use and disposal. However, in practice, P.I.'s with separate authorizations may occasionally need or find it desirable to share laboratory space and use different radionuclides in the same room(s). According to the State and NRC Guidelines, "shared space" means any two or more authorized investigators who are in the same room (as defined by a space fully enclosed by walls and doors), whether or not bench space and/or equipment within the room is actually shared. For example, if two P.I.'s have separate bench space within the same room, it is "shared" even if the space is divided by lab bench or invisible line that is never crossed by personnel from either lab. The Radiation Safety Committee must formally approve such arrangements and the Radiation Safety Officer is authorized to deny use of radionuclides by P.I.'s involved in such space arrangements until a proposal for sharing space has been submitted to and approved by the RSC. The principal purpose of such shared space arrangements is to ensure the safety of personnel who may be working for one P.I. but who are exposed to radionuclides from another P.l.'s radionuclide activities as a result of sharing space within the same room. Personnel in each lab must have a mechanism to be informed about and protected from the radiation activities of other labs. Thus, even if only one of the two or more P.I.'s who are sharing space is authorized for radionuclides, all parties must enter into a shared space agreement.

After reviewing the guidelines listed below with all parties involved, complete the form and submit to the RSO. All involved parties must sign this agreement which certifies that the guidelines put for will be adhered to by all participants.

The guidelines for P.I.'s who are proposing use of radionuclides in a shared laboratory space are as follows:

- A proposal must be submitted to the RSC at least two weeks prior to its next meeting describing the protocols for sharing laboratory space. The proposal should be developed, written and co-signed by all P.I.'s involved in the shared space arrangement. A cover letter also co-signed by the participants should briefly justify the need for the shared lab space and include responses to all the information requested in these guidelines.

- The proposal must include diagrams of all involved laboratory space, indicating the specific locations for radionuclide use, storage of stock vials, waste storage and disposal.

- Each laboratory will keep separate logbooks recording receipt of stocks, storage and use of radionuclides, disposal of stock vials and waste, swipe tests and personal exposures.

- A specific designated individual in each laboratory must be named and will be responsible for keeping the records and monitoring radiation exposure and use for

each P.I. These individuals will be kept informed of any spills or other mishaps involving radionuclides and will report any incidents to the other designated individuals, to the P.I.'s of each laboratory, and to the Radiation Safety Officer. The Environmental Health & Office should be notified if the status of the designated individual(s) is changed.

- A joint laboratory meeting of all personnel is encouraged to conduct an annual review of radiation use, safety procedures and laboratory space arrangements.

- If one or more of the participating laboratories is using radionuclides in the shared space that require personal monitoring (e.g., quarterly dosimeters) all personnel in each participating laboratory may also be monitored.

- Following any spill, mishap, or elevated swipe test results, a joint laboratory meeting of all personnel will be conducted. The incident will be discussed and radiation safety procedures will be reviewed.

- Prior to instituting any major changes in radionuclide use or the shared space agreement, a proposal by the participating laboratories must be submitted to the RSC for its approval.

- If any bench or other work space and/or equipment are actually shared among labs within the shared space, the following also applies: In addition to normal swipe testing, swipe testing of the entire shared space will be conducted for the month that radioactive material is used. These results will be recorded in each laboratory's records. The entire shared space will be surveyed after any aberrant readings and the results recorded in each laboratory's log book. If this section does not apply, a statement to that effect should be included in the cover letter.

- If any bench or other workspace and/or equipment are actually shared by personnel within the shared room(s), the following also applies: A rational physical plan for safe and minimal radionuclide use in the room should be developed. One of two models should be considered in designating the radionuclide areas to be used. One approach would be to separate areas of use by type of radionuclide, e.g., one area for ^{32}P, another area for ^{51}Cr. Particularly with radionuclides requiring special monitoring and/or shielding, this model may work best for multiple radioinuclide laboratories. A second model would be to cluster all radionuclide use to one or a few areas of the space, leaving the rest of the laboratory "clean". This model may also have advantages in certain cases. Whichever arrangement is chosen, justify the choice in the proposal and describe how records and safety procedures will be maintained. If this section does not apply, a statement to that effect should be included in the cover letter.

- Other arrangements may also be specified by the P.I. or by the RSC and/or the Radiation Safety Officer following their review, as deemed necessary.

DARTMOUTH COLLEGE SHARED SPACE AGREEMENT

Date: _____

Laboratories and Designated Individuals participating in the Shared Space Arrangement (print or type)

*Principal Investigator 1:_____
(*primary contact person*)

Designated Individual:_____

Principal Investigator 2: _____

Designated Individual: _____

Principal Investigator 3: _____

Designated Individual: _____

Principal Investigator 4: _____

Designated Individual: _____

Principal Investigator 5: _____

Designated Individual: _____

Building:_____ Laboratory Room No(s):_____