# RADIATION PROTECTION PROGRAM

UNIVERSITY *of* NEW HAMPSHIRE

**OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY**

**WWW.UNH.EDU/EHS**

# TABLE OF CONTENTS

1.0 ORGANIZATIONAL OUTLINE FOR RADIATION PROTECTION…….3

2.0 TRAINING REQUIREMENTS……14

3.0 RADIATION PROTECTION PROGRAM MAINTENANCE……19

4.0 RADIATION MONITORING INSTRUMENTS…….…30

5.0 MATERIAL RECEIPT AND ACCOUNTABILITY…….…..36

6.0 OCCUPATIONAL AND PUBLIC DOSES…….....39

7.0 SAFE USE OF RADIONUCLIDES AND EMERGENCY PROCEDURES…….....43

8.0 SURVEYS AND MONITORING…….....56

9.0 LEAK TEST PROCEDURES…….....65

10.0 TRANSPORTATION…….…..67

11.0 WASTE MANAGEMENT PROCEDURES……69

12.0 WASTE MINIMIZATION……72

13.0 SPECIAL CONSIDERATIONS FOR LABORATORY ANIMAL USE……74

## RADIATION PROTECTION PROGRAM

The University of New Hampshire (UNH) is committed to a Radiation Protection Program (RPP) of the highest quality. Likewise UNH hereby commits to full and complete compliance with all relevant requirements in New Hampshire Rules For The Control Of Radiation. This Radiation Protection Program is designed to control operations conducted at the UNH Research and Education Facilities that may result in the potential exposure of UNH personnel, members of the general public and/or the environment to ionizing radiation. The University of New Hampshire's commitment to the RPP is based on the fundamental principle that levels of radioactivity to be used, and exposures to all sources of ionizing radiation, are to be maintained **As Low As Reasonably Achievable (ALARA)**.

# 1.0 ORGANIZATIONAL OUTLINE FOR RADIATION PROTECTION

Superior, consistent performance in radiological control is achieved when: qualified personnel follow proven procedures, management actively monitors the workplace, and radiation safety personnel audit activities to assess the quality of work from a compliance and performance standpoint. Regular review and informed interest by senior management is required to achieve a superior Radiation Protection Program.

## 1.1 DESIGNATION DESCRIPTION

**Radiation (Radiological) Worker**:
These individuals will perform actual laboratory and/or process operations using radioactive materials under the direction of an Authorized User. Radiation Worker responsibilities are outlined in Section 1.3.1.

**Authorized User:**
This specification of Radiation Worker will oversee laboratory or process operations and assist other Radiation Workers in the radiological aspects of the job or task. An appointed Authorized User (AU) will assume the duties of the Radiation Safety Officer (RSO) upon direction by the RSO. It is the responsibility of the AU to directly oversee laboratory personnel and operations as to ensure compliance with radiological control policies and procedures. AUs will be approved by the Radiation Safety Committee.

**Radiation Safety Officer**:
The Radiation Safety Officer (RSO) will be responsible for overseeing the Radiation Protection Program and the requirements of the radioactive materials license. The responsibilities of the RSO are outlined in Section 1.3.2.

**Radiation Safety Staff:**
The Radiation Safety Staff consists of UNH and/or Contract personnel who assist the RSO in the management of the Radiation Protection Program.

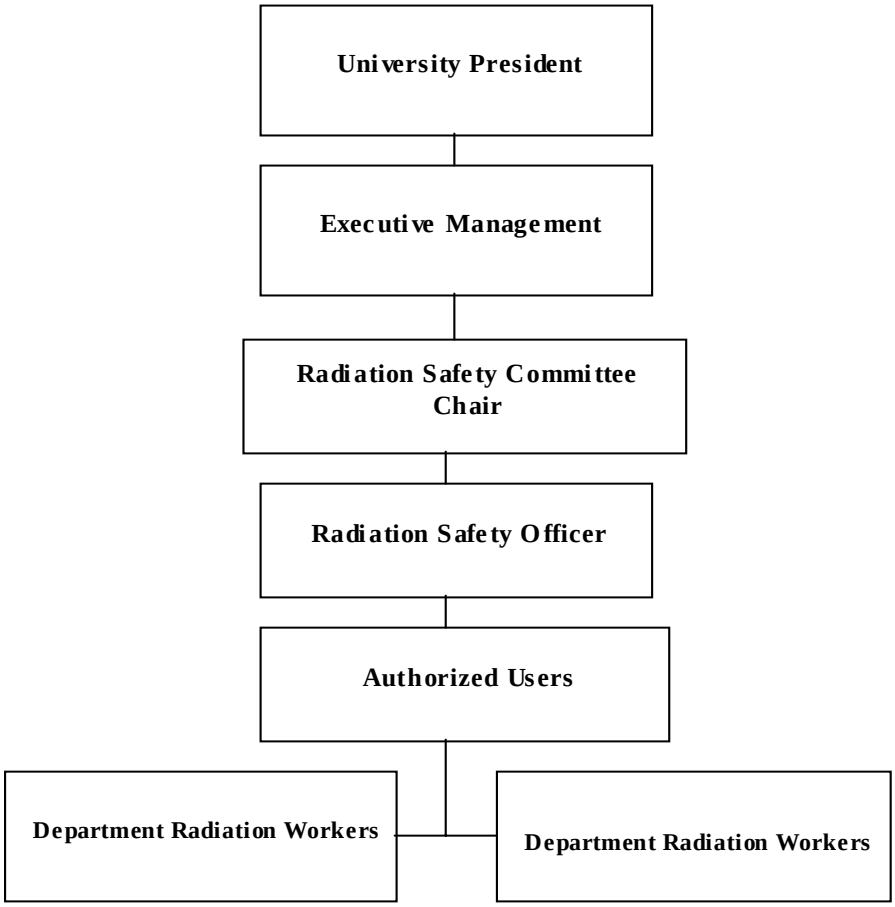
**Radiation Safety Committee:**
The Radiation Safety Committee (RSC) is a body consisting of the RSO, an Executive Manager and persons trained and experienced in the safe use of radioactive materials. The RSC is responsible for working with Executive Management and the RSO in implementing and managing the Radiation Protection Program.

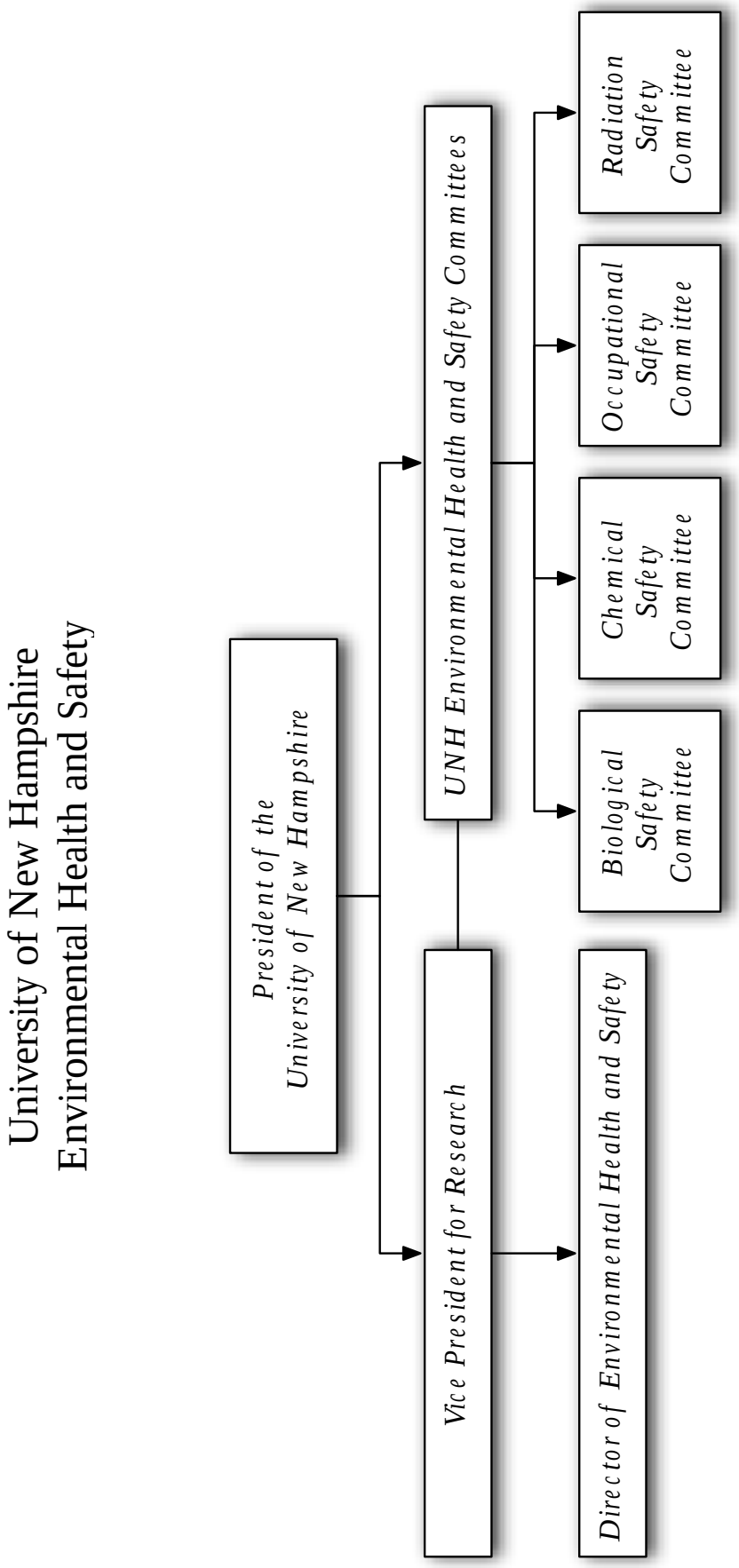
**Executive Management:**
Executive Management is the individual at the senior management level who is responsible for the oversight of the facility's radiation safety program and has the ultimate responsibility for the license and the activities associated with the

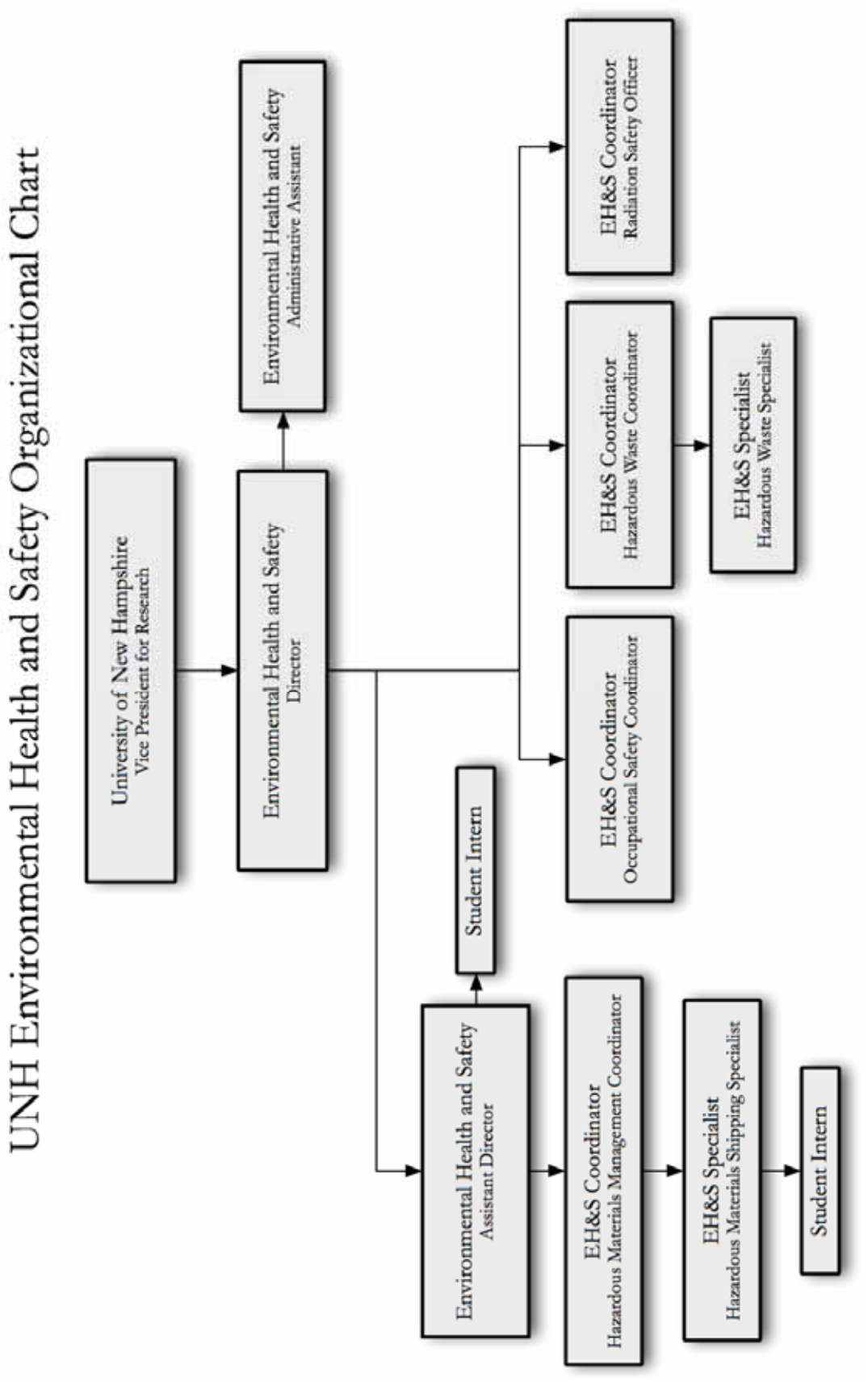
license. Executive Management has an important role in implementing and managing the radiation safety program and reports to the UNH President.

## 1.2 ORGANIZATION CHART

The following organizational chart depicts the control hierarchy of the Radiation Protection Program:




University of New Hampshire
Environmental Health and Safety
President of the University of New Hampshire
Vice President for Research
Director of Environmental Health and Safety
UNH Environmental Health and Safety Committees
Biological Safety Committee
Chemical Safety Committee
Occupational Safety Committee
Radiation Safety Committee


UNH Environmental Health and Safety Organizational Chart
University of New Hampshire
Vice President for Research
Environmental Health and Safety
Director
Environmental Health and Safety
Administrative Assistant
EH&S Coordinator
Radiation Safety Officer
EH&S Coordinator
Hazardous Waste Coordinator
EH&S Specialist
Hazardous Waste Specialist
EH&S Coordinator
Occupational Safety Coordinator
Student Intern
Environmental Health and Safety
Assistant Director
EH&S Coordinator
Hazardous Materials Management Coordinator
EH&S Specialist
Hazardous Materials Shipping Specialist
Student Intern

UNIVERSITY of NEW HAMPSHIRE

January 3, 2005

TO: All Employees

FROM: Ann Weaver Hart
President

SUBJECT: Delegation of Authority for Radiation Safety Officer

Sam Siegel has been appointed Radiation Safety Officer in the Office of Environmental Health and Safety and is responsible for ensuring safe use of radioactive material. The Radiation Safety Officer is responsible for managing the radiation protection program; identifying radiation safety problems, initiating, recommending, or providing corrective actions; verifying implementation of corrective actions; and ensuring compliance with regulations for the use of radioactive material. The Radiation Safety Officer is herby delegated the authority necessary to meet these responsibilities.

The Radiation Safety Officer has the authority to immediately stop any operations involving the use of radioactive material in which health and safety may be compromised or may result in non-compliance with New Hampshire Bureau of Radiological Health requirements.

OFFICE OF THE PRESIDENT
Thompson Hall 105 Main Street Durham, New Hampshire 03824 Phone: 603-862-2450 Fax: 603-862-3060

## 1.3 RESPONSIBILITIES

### 1.3.1 RADIATION (RADIOLOGICAL) WORKERS

Radiation Workers will be familiar with this Radiation Protection Program and all relevant UNH procedures. As a rule, the following responsibilities will be met by all Radiation Workers:

- Keep exposures to ionizing radiation As Low As Reasonably Achievable (ALARA).
- Conduct a whole body survey prior to exiting a restricted area or whenever contamination is suspected.
- Wear the proper personal protective equipment (PPE) when working with or handling radioactive materials (i.e. tyvek body suits and latex gloves). PPE will not be worn outside of controlled areas.
- There will be no eating, drinking, smoking, chewing gum, eating utensils or application of cosmetics in areas under radiological control. No evidence of the aforementioned activities will be discarded into trash receptacles in controlled areas.
- Maintain good personal hygiene. Wash hands and wrists thoroughly after 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 in unsealed form. Contaminated areas must be decontaminated immediately.
- All radioactive samples, contaminated equipment and waste containers will be appropriately labeled.
- The RSO or designee will be immediately notified of any personal contamination, internal exposure or a major spill involving radioactive materials.
- Report all findings during contamination surveys in units of radioactivity (e.g. DPM or microcuries).
- Report all evidence of non-compliance to the RSO, RSC or State of New Hampshire.

### 1.3.2 RADIATION SAFETY OFFICER

The Radiation Safety Officer (RSO) is charged with the implementation, maintenance, oversight and periodic modification of the Radiation Protection Program. The RSO's duties and responsibilities also include ensuring radiological safety and compliance with State of New Hampshire, Nuclear Regulatory Commission (NRC) and Department of Transportation (DOT) regulations and the conditions of the license. In support of this requirement the RSO will:

- Maintain surveillance of overall activities involving radioactive material, including monitoring and surveying of all areas in which radioactive material is used.

- Ensure compliance with rules and regulations, license conditions, and the conditions of project approvals authorized by the Radiation Safety Committee.

- Monitor and maintain absolute and other special filter systems associated with the use, storage, or disposal of radioactive material.

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

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

- Distribute and process personnel radiation monitoring equipment, determine the need for and evaluate bioassays, monitor personnel radiation exposure and bioassay records for trends and high exposures, notify individuals and their supervisors of radiation exposures approaching maximum permissible amounts, and recommend appropriate remedial action.

- Conduct training programs and otherwise instruct personnel in the proper procedures for the use of radioactive material prior to use, at periodic intervals (refresher training), and as required by changes in procedures, equipment, regulations, etc.

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

- Store radioactive materials not currently in use, including waste.
- Perform or arrange for leak tests on all sealed sources and calibration of radiation survey instruments.
- Maintain an inventory of all radioisotopes at the institution and limit the quantity of radionuclides at the institution to the amounts authorized by the license.
- Immediately terminate any 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 above.
- Hold periodic meetings with, and provide reports to, the Radiation Safety Committee and Executive Management.

### 1.3.3 RADIATION SAFETY STAFF

The UNH Radiation Safety Staff (RSS) shall support the RSO in his or her daily duties to ensure compliance with all local, state, federal, and license specific requirements or commitments. The RSS shall adhere to all procedural guidelines and requirements for program maintenance found in this Radiation Protection Program.

### 1.3.4 RADIATION SAFETY COMMITTEE

The Radiation Safety Committee (RSC) is a University Standing Committee that is responsible for the oversight of the University Radiation Protection Program. In fulfillment of this role, the RSC promulgates policies, rules and procedures for the safe use of radioactive material. The RSC has the authority to grant, deny, or withdraw permission for the use of radioactive materials within the University. It is the intent of the University that no use of radioactive materials proceeds without the knowledge and approval of the RSC. The committee will consist of: the Director of Environmental Health and Safety (non-voting member), the Radiation Safety Officer (non-voting member), Authorized Users (department representatives, voting members), an Executive Management representative, and an Administrative representative. The Radiation Safety Committee size and composition shall be large enough to represent the spectrum of radiation users across the University. The membership process consists of formal appointment to the RSC by the Vice President for Research. Members shall be appointed for a renewable term of three

years. Nominations for membership may be made by existing Committee members to provide representation from major academic, clinical and research areas that use radiation sources. Qualified nominees shall include principal investigators and/or experienced professionals, proficient in the use and handling of radioactive materials, who are knowledgeable about regulatory compliance and University policy related to radioactive material use. Members shall have at least 40 hours of training and experience in the safe handling of Radioactive Material. This training needs to include the characteristics of ionizing radiation, units of radiation dose and quantities, operation of detection instrumentation, and biological hazards of exposure to radiation that are appropriate to the type and form of Radioactive Material to be used. The quorum for the Radiation Safety Committee will consist of the Chair of the Committee, the Radiation Safety Officer, the Executive Management representative and fifty percent of the committee members that represent departments using radioactive materials. A written record of all meetings will be maintained by the Chairperson.

Specific duties and responsibilities of the RSC include:

- Review the training and experience of the proposed Authorized Users and the Radiation Safety Officer (RSO) to determine that their qualifications are sufficient to enable them to perform their duties safely and in accordance with the regulations and the license.
- Review and approve or deny all requests for authorization to use radioactive material within the institution, maintaining consistency with the regulations, the license and the As Low As Reasonably Achievable (ALARA) philosophy.
- Prescribe special conditions that will be required during a proposed method of use of radioactive material such as requirements for bioassays, physical examinations of users and special monitoring procedures.
- Review quarterly, the RSO's summary report of the occupational radiation exposure records of all personnel.
- Establish programs to ensure that all persons whose duties may require them to work in or frequent areas where radioactive materials are used (security, housekeeping and Facilities) are appropriately trained.
- Review, at least annually, the RSO's summary report of the entire radiation safety program to determine that all activities are being conducted safely, in accordance with Radiological Health Section regulations and the conditions of the license, and are consistent with the ALARA program and philosophy. The review must include an examination of records, reports from the RSO, results of program audits,

written safety procedures and the adequacy of the management control system.

- Recommend remedial action to correct deficiencies identified in the radiation safety program.
- Maintain written minutes of all Committee meetings, including members in attendance and members absent, discussions, actions, recommendations, decisions and numerical results of all votes taken.
- Conduct periodic audits, in conjunction with the RSO, of the radiation protection program. Review findings of annual audits and act upon recommendations.

To obtain authorization to procure and use radioactive material, a prospective Authorized User must complete an "Application For Radioactive Material Users Permit" and the Radioactive Materials User Training and Experience Resume. The Radiation Safety Officer will review the completed application and resume, evaluating the facilities and equipment available, the training and experience of the applicant and staff for the proposed use, the details of the work to be performed, survey instrumentation required, personnel monitoring, emergency procedures and waste disposal. After the review, including any necessary modifications and consultations with the Authorized User, the application will be forwarded to the Radiation Safety Committee with a recommendation for approval or disapproval. The application must be approved by a majority vote. The procedures approved in the application become the conditions under which the researcher and his/her personnel are authorized to use radioactive material. The RSO will then issue a "Radioactive Materials User Permit". Any subsequent change in procedure regarding the use, storage or disposal of sources must be reviewed and approved in writing by the Radiation Safety Officer prior to instituting the change.

### 1.3.5 EXECUTIVE MANAGEMENT

Effective radiation safety program management is vital to achieving safe and compliant operations. UNH believes that consistent compliance with applicable regulations provides reasonable assurance that licensed activities will be conducted safely. UNH also recognizes that effective management will result in increased safety and compliance.

"Management" refers to the processes for conducting and controlling the radiation safety program and to the individuals who are responsible for those processes and have authority to provide necessary resources to ensure safety and to achieve regulatory compliance.

To ensure adequate management involvement, a duly authorized executive management representative must acknowledge management's commitments and responsibility for the following:

- Radiation safety, security and control of radioactive materials, and compliance with regulations;
- Completeness and accuracy of radiation safety records and all information provided to the State of New Hampshire;
- Knowledge about the contents of the license and application;
- Compliance with current State of New Hampshire, NRC and Department of Transportation (DOT) regulations and UNH's operating and emergency procedures;
- Commitment to provide adequate resources (including space, equipment, personnel, time, and contractors) to the radiation protection program to ensure that public and workers are protected from radiation hazards and compliance with regulations is maintained;
- Selection and assignment of qualified individuals to serve on the Radiation Safety Committee and to serve as the Radiation Safety Officer for licensed activities;
- Prohibition against discrimination of employees engaged in protected activities;
- Commitment to provide information to employees regarding the employee protection and deliberate misconduct provisions in He-P 4019 and 4020; and
- Obtaining the State of New Hampshire's prior written consent before transferring control of the license.

## 2.0 TRAINING REQUIREMENTS

Individuals working in or frequenting restricted areas must meet the following applicable training requirements. These training requirements shall be continually reviewed and revised in order to provide function-specific and need-specific training. Therefore these requirements may be modified. Training classes shall be conducted by the Radiation Safety Officer, or someone of similar training and experience, in accordance with outlines reviewed and approved by the Radiation Safety Committee.

### 2.1 FREQUENCY OF TRAINING

As a rule, Radiation Safety training will be required:

1. Before assuming duties with, or work in the vicinity of, radioactive materials;
2. Whenever there is a significant change in duties, regulations, or the terms of the license;
3. Annually (refresher training).

### 2.2 TYPES OF TRAINING

In order to meet function specific training requirements, the following types of training will be offered, at a minimum:

1. Ancillary Personnel Radiation Safety Awareness Training, Initial.
2. Radiation Worker Training, Initial.
3. Ancillary Personnel Radiation Safety Awareness Training, Refresher.
4. Radiation Worker Training, Refresher.
5. Contractor Radiation Awareness.

An examination is required for Radiation Worker training with a minimum passing grade of eighty percent.

### 2.3 TOPICS

As previously discussed, the topics that are covered in any training will be designed to meet function-specific training needs. The following topics are samples of material that may be covered in one of the classes defined in 2.2.

#### 2.3.1 GENERAL INFORMATION

A. General Awareness
   1. Signs and labels.
   2. Notice to Employees.
   3. License Scope.
   4. Emergency response.
   5. Restricted access, Facility requirements.

B. Radiation Safety
1. Radiation versus Contamination.
2. Internal versus External exposure.
3. Biological effects of radiation.
4. ALARA philosophy.
5. Use of time, distance, and shielding to minimize exposure.

C. Regulatory requirements
1. Organization of Radiation Safety Program.
2. Material control and accountability.
3. Personnel dosimetry.
4. Radiation safety program audits.
5. Materials Transfer and disposal.
6. Recordkeeping requirements.
7. Surveys: frequency, type and responsibilities.
8. Postings.
9. Labeling of containers.
10. Handling and reporting of incidents or events.
11. Licensing and inspection by the NH Radiological Health Section.
12. Need for complete and accurate information.
13. Employee protection.
14. Deliberate misconduct, disciplinary actions.

### 2.3.2 LICENSE-SPECIFIC PROGRAM ELEMENTS

A. Authorized Users and Radiation Workers.

B. Ordering and receiving radioisotopes.

C. Applicable regulations and License conditions.

D. Areas where radioactive material is used or stored, Restricted Areas.

E. Potential hazards associated with radioactive material in each area where the individuals will work.

F. Radiation safety procedures.

G. UNH Rules and Procedures.

H. Each individual's obligation to report unsafe conditions to the RSO.

I. Appropriate response to spills, emergencies or other unsafe conditions.

J. A worker's right to be informed of occupational radiation exposure and bioassay results, if applicable.

K. Locations where UNH has posted or made available: notices, copies of pertinent regulations, and copies of pertinent licenses and license conditions (including applications and applicable correspondence), as required by State regulations.

L. Emergency procedures:
1. RSO name and telephone number.
2. Immediate steps to prevent or control spread of contamination.
3. Spill response instructions, decontamination.

M. Survey program:
1. Survey instrument accessibility.
2. Responsibility.
3. Types, contamination and area.
4. Frequency.
5. Levels of contamination.
6. Personnel, hands, shoes.
7. Records.

N. Waste
1. Liquids.
2. Solids.
3. Sanitary sewer release restrictions.
4. Processing and disposal.
5. Storage.
6. Decay-in-storage.
7. Waste storage surveys.
8. Volume reduction strategies.
9. Records.

O. Dosimetry
1. Whole body.
2. Extremities.
3. Lost or replacement badges and dose assessment.
4. Bioassay procedures.
5. Records.

P. Instrumentation
1. Survey meters
    a. Use and care.
    b. Calibration frequency.
    c. Use of check sources, CPM Conversion.

2. Analytical instruments
    a. Liquid scintillation counters.
    b. Gamma counters.

Q. Procedures for receiving packages containing radioactive materials
1. Normal business hours.
2. Off-hours restriction.
3. Notification of user and RSO.
4. Security issues.
5. Exposure levels.
6. License possession limits.
7. Receipt of damaged or unauthorized packages.

R. Procedures for opening and examining packages
1. Package condition, leakage and contamination.
2. Monitoring packages.
3. Monitoring packing materials.
4. Personal Protective Equipment.
5. Transferring material to users.

S. Animal experiments
1. Description of facilities.
2. Safety instructions, including handling of animals, waste, carcasses and cleaning and decontamination of cages.
3. Security.

T. Sealed sources
1. Leak test requirements.
2. Inventory requirements.
3. Exempt quantities.
4. Records.

U. Other topics, as applicable

V. Question and answer period, evaluation of training

### 2.3.3 FOR LABORATORY SAFETY AND USE OF RADIOISOTOPES

A. Control procedures for obtaining permission to use radioactive materials at the facility; protocol limitations and requirements

B. Protective clothing and what laboratory apparel to wear and what equipment to use.

C. Limitations and conditions relative to handling unsealed licensed material and what laboratory equipment to use when working with such material (shielding, engineering control requirements, etc.).

D. Routine survey and monitoring procedures to be followed for contamination control.

E. Emergency procedures concerning spills, fires, release of material, and/or accidental contamination of personnel.

F. Decontamination procedures to use and whom to contact in case of an emergency.

G. Instructions concerning transfer of licensed materials between rooms, halls, corridors, or buildings.

H. Requirements for storage, labeling of containers, and identification of areas where licensed materials are used.

I. Personnel monitoring devices to use, where to obtain them, and exchange procedures and exposure results.

J. Waste disposal procedures to follow, limitations for disposal of liquid or solid wastes, and procedures to use for waste storage. If protocol involves experiments with animals, procedures for cleaning animal quarters and handling animal excreta and carcasses for disposal shall be included.

K. Records to be maintained on use and disposal of licensed materials.

L. Prohibition of pipetting by mouth, eating, smoking, and drinking in areas where licensed materials are used.

## 3.0 RADIATION PROTECTION PROGRAM MAINTENANCE

This program shall be reviewed for implementation and content no less than annually. The results of this audit shall be maintained on file for review and inspection.

An audit is conducted, in part, to fulfill the requirements of He-P 4020.04 for an annual review of the content and implementation of the UNH Radiation Protection Program. It should also identify program weaknesses and allow UNH to take early corrective actions (before a Radiological Health Section inspection). During an audit, the auditor needs to keep in mind not only the requirements of the Radiological Health Section's regulations, but also the UNH commitments in its applications and other correspondence with regulators. The auditor should also evaluate whether UNH is maintaining exposures to workers and the general public As Low As is Reasonably Achievable (ALARA) and, if not, make suggestions for improvement.

The RSO or designee will conduct annual audits. This individual will be selected based on his/her training and experience and the focus of the audit as directed by the RSC. Therefore training and experience may vary depending on the needs of the radiation safety program. Records of these audits will be maintained for 3 years after the audit and will include date of the audit, name(s) of person(s) who conducted the audit, persons contacted by the auditor, areas audited, audit findings, corrective actions, and follow-up.

Minimum qualifications include at least five years experience as a Radiation Safety Officer or Authorized User of radioactive materials, and at least five years experience in auditing radiation safety related procedures, systems and records.

The sample form (found in 3.2), or other appropriate document, can be used to document the annual audit of the Radiation Protection Program. Guidance follows on completing each section of the form (3.1). In the "remarks" portion of the form, note any deficiencies that were identified and the corrective actions taken (or to be taken).

### 3.1 Audit Scope

#### 3.1.1 Section 1, Audit History.

Enter the date of the last audit, whether any deficiencies were identified, and whether actions were taken to correct the deficiencies.

#### 3.1.2 Section 2, Organization and Scope of Program.

Give a brief description of the organizational structure, noting any changes in personnel. Describe the scope of licensed activities. Check whether the Radiation Safety Officer (RSO) is the person identified in the license and fulfills the duties specified in the license.

#### 3.1.3 Section 3, Training, Retraining, and Instructions to Workers.

Ensure that workers have received the training required by the RPP. Be sure that, before being permitted to use by-product material, the user has received training and has a copy of the UNH safe use and emergency procedures. Note whether refresher training is conducted in accordance with RPP commitments. **Ensure that each worker has access to a copy of UNH current procedures and policies, and by interview and/or observation of selected workers that he/she can implement them.**

### 3.1.4 Section 4, Audits.

Verify that audits fulfill the State requirements, are conducted in accordance with UNH commitments, and are properly documented.

### 3.1.5 Section 5, Facilities.

Verify that UNH facilities are as described in license documents.

### 3.1.6 Section 6, Materials.

Verify that the RSO authorizes the quantities and types of by-product material that UNH possesses.

### 3.1.7 Section 7, Leak Tests.

Verify that all sealed/plated foil sources are tested for leakage at the prescribed frequency and in accordance with any UNH commitments. Records of results should be maintained.

### 3.1.8 Section 8, Inventories.

Verify that inventories are conducted at least once every 6 months to account for all sources and stock material; physical inventory records should be maintained.

### 3.1.9 Section 9, Radiation Surveys.

Verify that UNH has appropriate, operable and calibrated survey instruments available, that the instruments are calibrated (at the required frequency) in accordance with license conditions and in accordance with State regulations. Calibration records must be retained for 3 years after the record is made. Check that radiation levels in areas adjacent to use are within regulatory limits. Records of surveys must be retained for 3 years after the record is made.

### 3.1.10 Section 10, Receipt and Transfer of Radioactive Material (Includes Waste Disposal).

Verify that packages containing by-product material, received from others, are received, opened, and surveyed in accordance with He-P 4022.16. Ensure that transfers are performed in accordance with State regulations. Records of surveys, receipt, and transfer must be maintained in accordance with State regulations.

### 3.1.11 Section 11, Transportation.

Determine compliance with Department of Transportation (DOT) requirements. Verify that radioactive packages are prepared, marked, and labeled in accordance with 49 CFR Parts 172 and 173 requirements. Verify that shipping papers are properly prepared, that they contain all needed information, and that they are readily accessible during transport (49 CFR 172.200, 201, 202, 203, 204 and 177.718).

### 3.1.12 Section 12, Personnel Radiation Protection.

Evaluate the UNH determination that unmonitored personnel are not likely to receive more than 10 percent of the allowable limits. Alternately, if personnel dosimetry is provided and required, verify that it complies with State requirements and UNH commitments. Review personnel monitoring records; compare exposures of individuals doing similar work; determine reasons for significant differences in exposures. If any worker declared her pregnancy in writing, evaluate the UNH compliance with He-P 4020.12 and 10 CFR 20.1208. Check whether records are maintained as required by He-P 4021 and 10 CFR 20.2101, 2102, 2103, 2104 and 2106.

### 3.1.13 Section 13, Auditor's Independent Measurements.

The auditor should make independent survey measurements and compare the results with those made or used by UNH during the previous year.

### 3.1.14 Section 14, Notification and Reports.

Check on the UNH compliance with the notification and reporting requirements in He-P 4019 and 4020. Ensure that the Radiation Workers are aware of the telephone number for the State of New Hampshire Radiological Health Section; (603) 271-4588 (8am-4:30pm) and **(800) 852-3411** (after hours and holidays), New Hampshire Bureau of Emergency Management's Emergency Response line **(603) 271-2231** and NRC's Emergency Operations Center; (301) 816-5100.

### 3.1.15 Section 15, Posting and Labeling.

Check for compliance with the posting and labeling requirements of He-P 4022.

### 3.1.16 Section 16, Recordkeeping for Decommissioning.

Check to determine compliance with State and Federal regulations.

### 3.1.17 Section 17, Bulletins and Information Notices.

Check to determine if the RSO is receiving bulletins, information notices, etc., from the Radiological Health Section. Check whether UNH took appropriate action in response to Radiological Health Section mailings.

### 3.1.18 Section 18, Special License Conditions or Issues.

Verify compliance with any special conditions on UNH's license. If UNH has started any unusual or new aspects of work, review and evaluate compliance with regulatory requirements.

### 3.1.19 Section 19, Continuation of Report Items.

This section is self-explanatory.

### 3.1.20 Section 20, Problems or Deficiencies Noted; Recommendations.

This section is self-explanatory.

### 3.1.21 Section 21, Evaluation of Other Factors.

Evaluate management's involvement with the Radiation Protection Program, whether the RSO has sufficient time to perform his/her duties, and whether UNH has sufficient staff to handle the workload and maintain compliance with regulatory requirements.

## 3.2 AUDIT SAMPLE CHECKLIST

Audit Report No.:

License No.:
Expiration Date:

Audit of activities at (Address):

Date of this Audit:

Summary of Findings and Action:

[ ] No deficiencies
[ ] Deficiencies
[ ] Action on previous deficiencies

Recommendations:

Auditor: Date:
(Signature)

1. AUDIT HISTORY [ ] N/A (N/A means "Not applicable" - Initial Audit)

   A. Last audit of this location conducted
   B. Problems/deficiencies identified during last two audits or two years, whichever is longer [ ] Y [ ] N
   C. Open problems/deficiencies from previous audits:
      Status Requirement Prob./Def. Corrective Action Taken [ ] Y [ ] N
      Open/Closed
   D. Any previous problem/deficiency not corrected or repeated [ ] Y [ ] N [ ]
      Explain:

2. ORGANIZATION AND SCOPE OF PROGRAM

   A. Briefly describe organizational structure
      1. Structure is as described in license documents [ ] Y [ ] N
      2. Multiple authorized locations of use [ ] Y [ ] N
      3. Briefly describe scope of activities involving byproduct material, frequency of use, staff size, etc. [ ] Y [ ] N

   B. Radiation Safety Officer
      1. Authorized on license [ ] Y [ ] N
      2. Fulfills duties as RSO [ ] Y [ ] N

   C. Use only by authorized individuals [ ] Y [ ] N

      Remarks:

3. TRAINING, RETRAINING, AND INSTRUCTIONS TO WORKERS

   A. Instructions to workers [ ] Y [ ] N
   B. Training program required [ ] Y [ ] N
   C. Training records maintained [ ] Y [ ] N
   D. Evaluation of individuals' understanding of procedures and regulations based on interviews, observation of selected workers [ ] Y [ ] N
      1. Each has access to an up-to-date copy of UNH safe use and emergency procedures

2. Adequate understanding of:
   Current safe use procedures [ ] Y [ ] N
   Emergency procedures [ ] Y [ ] N

E. State Regulations
Workers cognizant of requirements for:
1. Radiation Protection Program [ ] Y [ ] N
2. Annual dose limits [ ] Y [ ] N
3. Radiological Health Section Forms [ ] Y [ ] N
4. 10% monitoring threshold [ ] Y [ ] N
5. Dose limits to embryo/fetus and declared pregnant women [ ] Y [ ] N
6. Procedures for opening packages [ ] Y [ ] N

Remarks:

4. INTERNAL AUDITS, REVIEWS OR INSPECTIONS

A. Audits are conducted [ ] Y [ ] N
1. Audits conducted by
2. Frequency

B. Content and implementation of the Radiation Protection Program reviewed annually [ ] Y [ ] N

C. Records maintained [ ] Y [ ] N

5. FACILITIES

A. Facilities as described in license application

Remarks:

6. MATERIALS

A. Isotopes, quantities, and use as authorized on license [ ] Y [ ] N

Remarks:

7. LEAK TESTS

A. Leak tests performed as described in correspondence with the Radiological Health Section (consultant, leak test kit, UNH performed) [ ] Y [ ] N
B. Frequency: every 6 months or other interval, as approved by Radiological Health Section [ ] Y [ ] N
C. Records with appropriate information maintained [ ] Y [ ] N

Remarks:

8. INVENTORIES

A. Conducted at 6-month intervals [ ] Y [ ] N
B. Records with appropriate information maintained [ ] Y [ ] N

Remarks:

9. RADIATION SURVEYS

A. Instruments and Equipment: [ ] Y [ ] N
   1. Appropriate operable survey instrumentation possessed or readily available [ ] Y [ ] N
   2. Calibrated as required [ ] Y [ ] N
   3. Calibration records maintained [ ] Y [ ] N

B. Briefly describe survey requirements:

C. Performed as required [ ] Y [ ] N
   1. Radiation levels within regulatory limits [ ] Y [ ] N
   2. Corrective action taken and documented [ ] Y [ ] N

D. Records maintained [ ] Y [ ] N

E. Protection of members of the public
   1. Adequate surveys made to demonstrate either (a) that the TEDE to the individual likely to receive the highest dose does not exceed 100 mrem in a year, or (b) that if an individual were continuously present in an unrestricted area, the external dose would not exceed 2 mrem in any hour and 50 mrem in a year [ ] Y [ ] N
   2. Unrestricted area radiation levels do not exceed 2 mrem in any one hour [ ] Y [ ] N
   3. Records maintained [ ] Y [ ] N

Remarks:

10. RECEIPT AND TRANSFER OF RADIOACTIVE MATERIAL (INCLUDES WASTE DISPOSAL)

A. Procedures describe how packages are received and by whom: [ ] Y [ ] N
B. Written package opening procedures established and followed [ ] Y [ ] N
C. If package shows evidence of degradation, monitor for contamination and radiation levels [ ] Y [ ] N [ ] N/A
D. Monitoring of degraded packages performed within time specified [ ] Y [ ] N [ ] N/A
E. Transfer(s) between licensees (including "disposal") performed [ ] Y [ ] N [ ] N/A
F. Records of receipt/transfer maintained [ ] Y [ ] N
G. Transfers within UNH to Authorized Users or locations performed as required [ ] Y [ ] N [ ] N/A
H. Package receipt/distribution activities evaluated for compliance with the New Hampshire Rules For The Control Of Radiation [ ] Y [ ] N [ ] N/A

Remarks:

11. TRANSPORTATION (49 CFR)

A. UNH shipments are:
1. Delivered to common carriers [ ] Y [ ] N
2. Transported in University vehicles [ ] Y [ ] N
3. No shipments since last audit [ ] Y [ ] N

B. Packages [ ] N/A
1. Authorized packages used [173.415, 173.416(b)] [ ] Y [ ] N [ ] N/A
2. Closed and sealed during transport [173.475(f)] [ ] Y [ ] N

C. Shipping Papers [ ] N/A
1. Prepared and used [172.200(a)] [ ] Y [ ] N
2. Proper {Shipping name, Hazard Class, UN Number, Quantity, Package Type, Nuclide, RQ, Radioactive Material, Physical and Chemical Form, Activity, Category of label, TI, Shipper's Name, Certification and Signature, and Emergency Response Phone Number} [172.200-204] [ ] Y [ ] N
3. Readily accessible during transport [177.718(e)] [ ] Y [ ] N

D. Vehicles [ ] Y [ ] N
1. Cargo blocked and braced [177.842(d)] [ ] Y [ ] N
2. Placarded, if needed [172.504] [ ] Y [ ] N
3. Proper overpacks, if used (shipping name, UN Number, labeled, statement indicating that inner package complies with specification package) [173.25] [ ] Y [ ] N

E. Any incidents reported to DOT [171.15, 171.16] [ ] Y [ ] N

Remarks:

12. PERSONNEL RADIATION PROTECTION

A. ALARA considerations are incorporated into the Radiation Protection Program [ ] Y [ ] N

B. Adequate documentation of determination that unmonitored occupationally individuals are not likely to receive >10% of allowable limit [ ] Y [ ] N [ ] N/A

**OR**

C. External dosimetry provided and required [ ] Y [ ] N [ ] N/A
1. Supplier Frequency
2. Supplier is NVLAP-approved [ ] Y [ ] N
3. Dosimeters exchanged at required frequency [ ] Y [ ] N

D. Occupational intake monitored and assessed [ ] Y [ ] N [ ] N/A

E. Reports [ ] N/A
1. Reviewed by Frequency
2. Auditor reviewed personnel monitoring records for period
3. Prior dose determined for individuals likely to receive doses [ ] Y [ ] N
4. Maximum exposures TEDE
5. Radiological Health Section Forms or equivalent [20.2104(d), 20.2106(c)]
    a. Agency Form ND 216 “Cumulative Occupational Exposure History” or equivalent [ ] Y [ ] N
    Complete: [ ] Y [ ] N
    b. Agency Form 217 “Occupational Exposure Record for a Monitoring Period” or equivalent [ ] Y [ ] N
    Complete: [ ] Y [ ] N
6. Worker declared her pregnancy in writing during inspection period (review records) [ ] Y [ ] N [ ] N/A
If yes, determine compliance with [ ] Y [ ] N
check for records [ ] Y [ ] N

F. Records of exposures, surveys, monitoring, and evaluations maintained [ ] Y [ ] N

Remarks:

13. AUDITOR'S INDEPENDENT MEASUREMENTS (IF MADE)

A. Survey instrument Serial No. last calibration

B. Auditor's measurements compared to Radiation Safety's [ ] Y [ ] N

C. Describe the type, location, and results of measurements:

14. NOTIFICATION AND REPORTS [ ] N/A

A. In compliance with reports to individuals, public and occupational, monitored to show compliance [ ] Y [ ] N [ ] N/A

B. In compliance with theft or loss regulations [ ] Y [ ] N [ ] None

C. In compliance with incidents regulations [ ] Y [ ] N [ ] None

D. In compliance with overexposures and high radiation levels [ ] Y [ ] N [ ] None

E. Aware of emergency telephone numbers [ ] Y [ ] N

15. POSTING AND LABELING

A. "Notice to Workers" is posted [ ] Y [ ] N

B. License documents are posted, or a notice indicating where documents can be examined is posted [ ] Y [ ] N

C. Other posting and labeling [ ] Y [ ] N

Remarks:

16. RECORD KEEPING FOR DECOMMISSIONING (if needed) [ ] N/A

A. Records of information important to the safe and effective decommissioning of the facility maintained in an independent and identifiable location until license termination [ ] Y [ ] N

B. Records include all information [ ] Y [ ] N

Remarks:

17. BULLETINS AND INFORMATION NOTICES

A. Receipt of Bulletins, Information Notices, Newsletters, etc. [ ] Y [ ] N

B. Appropriate action taken in response to Bulletins, Information Notices, etc. [ ] Y [ ] N

Remarks:

18. SPECIAL LICENSE CONDITIONS OR ISSUES [ ] N/A

A. Review special license conditions or other issues, and describe findings:

B. Problems/deficiencies identified at UNH facilities other than at audit location:

C. Evaluation of compliance:

19. CONTINUATION OF REPORT ITEMS [ ] N/A
(If more space is needed, use separate sheets and attach to report.)

20. PROBLEMS OR DEFICIENCIES NOTED; RECOMMENDATIONS [ ] N/A

***Note:*** Briefly state (1) the requirement and (2) how and when violated. Provide recommendations for improvement.

21. EVALUATION OF OTHER FACTORS

A. Senior UNH management is appropriately involved with the Radiation Protection Program and/or Radiation Safety Officer (RSO) oversight [ ] Y [ ] N

B. RSO has sufficient time to perform his/her radiation safety duties and is not too busy with other assignments [ ] Y [ ] N

C. UNH has sufficient radiation safety staff [ ] Y [ ] N

Remarks/recommendations:

## 4.0 RADIATION MONITORING INSTRUMENTS

Radiation detection instrumentation will be available in sufficient types and quantities as to support the scope of UNH operations involving radioactive materials and/or radiation producing equipment. The following tables detail common instrumentation and relative efficiencies for differing types of radiation.

| **Portable Instruments Used for Contamination and Ambient Radiation Surveys** | | | |
|---|---|---|---|
| *Detector* | *Radiation* | *Energy Range* | *Efficiency* |
| Exposure Rate Meters | Gamma, X-ray | Meter dependent | N/A |
| Count Rate Meters: GM | Alpha | Dependent on window thickness | Moderate |
| | Beta | Dependent on window thickness | Moderate |
| | Gamma | Dependent on window thickness | < 1% |
| NaI Scintillator | Gamma | Dependent on crystal thickness | Moderate |

| **Stationary Instruments Used to Measure Wipe, Bioassay and Effluent Samples** | | | |
|---|---|---|---|
| *Detector* | *Radiation* | *Energy Range* | *Efficiency* |
| Liquid Scintillation Counters | Alpha | All energies | High |
| | Beta | All energies | High |
| | Gamma | | Moderate |
| Gamma Counters | Gamma | All energies | High |

Table information adapted from The Health Physics & Radiological Health Handbook , Third Edition, Edited by Schleien, Slaback and Birky, 1998

UNH currently maintains the following list of portable radiation detection instrumentation. This list is subject to change based on operations and the recommendations of the Radiation Safety Committee. Portable instruments will be calibrated at yearly intervals by a licensed calibration vendor. At a minimum, portable survey instrumentation will be readily available for use within all laboratories using penetrating sources of radiation (> 250 keV). The instrument make and model will be determined by the department purchasing the instrument, but will be capable of detecting the types of radioactive materials employed in that laboratory. The RSC will validate the appropriateness of the number and type of available instrumentation during the procedure review process. In addition, stationary radiation detection equipment (e.g. liquid scintillation counters) will be available in sufficient quantity to support research in any department or building.

## PRESENT INSTRUMENT INVENTORY

| INSTRUMENT MAKE | MODEL | SERIAL NUMBER |
|---|---|---|
| BICRON | RSO-5 | C033F |
| EBERLINE | ASP-2 | 647 |
| EBERLINE | ASP-2E | 655/725485 |
| EBERLINE | ESP | 1404 |
| EXPLORANIUM | GR-130 | 9895 |
| LUDLUM | 3 | 111766 |
| LUDLUM | 3 | 163195 |
| EBERLINE | MS-2 | 1649 |
| EBERLINE | MS-3 | 104 |
| LUDLUM | 3 | 119162 |
| LUDLUM | 3 | 83854 |
| JOHNSON | GSM-105 | 7750 |

| | | |
|---|---|---|
| JOHNSON | GSM-115 | 5097 |
| LUDLUM | 3 | 107104 |
| EBERLINE | ESP | 02511 |
| LUDLUM | 3 | 130655 |
| EBERLINE | E-120 | 10988 |
| LUDLUM | 3 | 130832 |
| RAD ALERT | MONITOR 4 | 19692 |
| MINI-MONITOR | 900 | 026980 |
| EBERLINE | ESP | 03020 |
| LUDLUM | 3 | 152983 |
| LUDLUM | 177 | 131112 |
| EBERLINE | E-120 | 13339 |
| | | |

## 4.1 FACILITIES AND EQUIPMENT FOR CALIBRATION OF DOSE RATE OR EXPOSURE RATE INSTRUMENTS

UNH will employ a fully licensed vendor to perform all dose rate and contamination monitor calibrations. Currently, CTI, a Division of Radiation Safety Control Services, Inc., 91 Portsmouth Avenue, Stratham, NH 03885-2468 (NH License #381R) or A.M. Calibrations, 15875 Gaither Dr. Gaithersburg, MD 20877 (License # MD-31-206-01) performs this service. UNH is not requesting license authority to perform such calibrations.

## 4.2 PROCEDURES FOR CALIBRATING, LIQUID SCINTILLATION COUNTERS, GAMMA COUNTERS, GAS FLOW PROPORTIONAL COUNTERS, AND MULTICHANNEL ANALYZERS

A radioactive sealed source or standard used for calibrating instruments will do the following:

- ✓ Approximate the geometry of the samples to be analyzed
- ✓ Have its apparent source activity traceable by documented measurements to a standard certified by National Institutes of Standards and Technology (NIST)
- ✓ Approximate the same energy and type of radiation as the samples that the calibrated device will be used to measure.

## 4.3 CALIBRATION RECORDS

Calibration records, for all survey instruments, will be provided by a licensed vendor and maintained by UNH Radiation Safety staff. The RSO maintains an electronic computer database of all radiation monitoring instruments that require annual calibration. The RSO receives calibration certificates from the licensed vendor and enters the date of calibration into this database. The licensed vendor also sends a reminder notification to the RSO that an instrument is due for calibration. The RSO then contacts the Authorized User to have the instrument sent for calibration. The Authorized User will be provided with a back-up survey instrument when his/her assigned instrument is sent for calibration.

## 4.4 AIR SAMPLER CALIBRATION

In order to assess accurately the air concentration of radioactive materials in a given location, the volume of air sampled and the quantity of contaminant in the sample must be determined. Accurate determination of the volume of air sampled requires standard, reproducible, and periodic calibration of the air metering devices that are used with air sampling instruments. The publication entitled “Air Sampling Instruments” found in the 7th Edition, American Conference of Governmental Industrial Hygienists, 1989, provides guidance on total air sample volume calibration methods acceptable to NRC staff, as supplemented below.

### 4.4.1 FREQUENCY OF CALIBRATION

Facilities committed to a routine or emergency air sampling program should perform an acceptable calibration of all airflow or volume metering devices at least annually (See NRC Regulatory Guide 8.25). UNH is committed to an annual calibration schedule, when needed.

In addition, special calibrations will be performed at any time there is reason to believe that the operating characteristics of a metering device have been changed, by repair or alteration, or whenever system performance is observed to have changed significantly. Routine instrument maintenance will be performed as recommended by the manufacturer. Primary or secondary standard instruments used to calibrate air sampling instruments will be inspected frequently for consistency of performance.

### 4.4.2 ERROR LIMIT FOR MEASUREMENT OF AIR SAMPLE VOLUME

Most methods of calibrating airflow or air volume metering devices require direct comparison to a primary or secondary standard instrument to determine a calibration curve or a correction factor. An example of a primary standard is a spirometer that measures total air volume directly with high precision by liquid displacement. An example of a secondary standard is a wet-test meter that has been calibrated against a primary standard. Primary standards are usually accurate to within ± 1% and secondary standards to within ± 2%.

The following are significant errors associated with determining the total air volume sampled:

$E_C$: The error in determining the calibration factor. (An acceptable estimate is the percentage error associated with the standard instrument used in the calibration.)

$E_S$: Intrinsic error in reading the meter scale. (An acceptable estimate is the percentage equivalent of one-half of the smallest scale division, compared to the scale reading.)

$E_t$: The percentage error in measurement of sampling time that should be kept within 1%.

$E_V$: The most probable value of the cumulative percentage error in the determination of the total air volume sampled. $E_V$: can be calculated from the following equation, provided there are no additional significant sources of errors:

$$E_V = [E_S^2 + E_C^2 + E_t^2]^{1/2}$$

The most probable value of the cumulative error $E_V$, in the determination of total volume, should be less than 20%. A sample calculation of the most probable value of the cumulative error in total volume measured is as follows: If accuracies of the scale reading, the calibration factor, and sample time are ± 4, 2, and 1%, respectively, and there are no other significant sources of error, the cumulative error would be:

$$E_V = [4^2 + 2^2 + 1^2]^{1/2} = 4.58\% \text{ or approx. } 5\%$$

If there are significant differences in pressure and temperature between the calibration site and the sampling site, appropriate corrections should be made using the ideal gas laws provided below:

$$V_S = V1 * (P1/760) * (273/T1)$$

where $V_S$ = volume at standard conditions (760 mm & $0^0$ C)
V1 = volume measured at conditions P1 and T1
T1 = temperature of V1 in $^0$K
P1 = pressure of V1 in mm Hg

### 4.4.3 DOCUMENTATION OF CALIBRATION OF AIR METERING DEVICES

UNH will maintain records of all routine and special calibrations of airflow or volume metering devices, including the primary or secondary standard used, method employed, and estimates of accuracy of the calibrated metering devices. All instruments should be clearly labeled as to the date and results of the most recent calibration and should include the appropriate correction factors to be used.

### 4.4.4 REFERENCES

1. Regulatory Guide 8.25, Revision 1, “Air Sampling in the Workplace.”

2. NUREG - 1400, “Air Sampling in the Workplace”

3. The Health Physics & Radiological Health Handbook, Revised Edition, Edited by Bernard Schleien,

4. ANSI N323A-1997, “Radiation Protection Instrumentation Test and Calibration.”

5. “Air Sampling Instruments,” American Conference of Governmental Industrial Hygienists, 1987

## 5.0 MATERIAL RECEIPT AND ACCOUNTABILITY

The Radiation Safety Officer, or designee, will approve all orders for radioactive material and will ensure that the requested material, quantities, manufacturer, and model are authorized by the UNH license and that the possession limits are not exceeded. All packages are to be delivered during normal operating hours. No after hours, weekend or holiday deliveries will be accepted. All carriers should be instructed to deliver radioactive packages directly to the RSO (11 Leavitt Lane, Perpetuity Hall, Durham, NH 03824).

| PACKAGE | CONTENTS | SURVEY TYPE | SURVEY TIME |
|---|---|---|---|
| **Labeled (White I, Yellow II, Yellow III)** | **Gas or Special Form greater than Type A quantities** | **Radiation Level** | **As soon as practicable, but not later than 3 hours after receipt** |
| **Labeled (White I, Yellow II, Yellow III)** | **Not Gas Nor Special Form greater than Type A quantities** | **Contamination & Radiation Level** | **As soon as practicable, but not later than 3 hours after receipt** |
| **Labeled (White I, Yellow II, Yellow III)** | **Gas or Special Form Less than Type A quantities** | **None** | **None** |
| **Labeled (White I, Yellow II, Yellow III)** | **Gas or Special Form greater than Type A quantities** | **Contamination** | **As soon as practicable, but not later than 3 hours after receipt** |
| **Not Labeled** | **Licensed Materials** | **None** | **None** |

### 5.1 INSTRUCTIONS TO PERSONNEL INVOLVED IN MATERIAL RECEIPT

#### 5.1.1 SHIPPING AND RECEIVING PERSONNEL

During normal working hours, immediately upon receipt of any package of licensed material, each package must be visually inspected for any signs of shipping damage such as crushed or punctured containers or signs of dampness. Any obvious damage must be reported to the RSO, or his/her designee, immediately. Do not touch any package suspected of leaking. Request the person delivering the package to remain until monitored by the RSO, or his/her designee.

Outside of normal working hours (e.g., nights, weekends, and holidays), deliveries will usually be handled by security personnel and should be refused.

Since certain packages of licensed material will have detectable external radiation, they should be sent immediately to a designated storage area, where they will be checked for contamination and external radiation level as soon as practical. They should not be allowed to remain in the receiving area any longer than necessary, as they may be a source of exposure for receiving personnel. If the instructions are not clear, or if there are questions regarding receiving packages containing radioactive material, please contact one of the following Safety Department representatives:

**Radiation Safety Officer –OR-**
**Director, Environmental Health and Safety**

## 5.2 PROCEDURE FOR SAFELY OPENING PACKAGES CONTAINING LICENSED MATERIALS

For packages received under this license, authorized individuals shall implement procedures for opening each package, as follows:

- ✓ Wear gloves to prevent hand contamination.
- ✓ Visually inspect the package for any sign of damage (e.g. crushed, punctured). If damage is noted, stop and notify the RSO.
- ✓ Check DOT White I, Yellow II, or Yellow III label or packing slip for activity of contents, to ensure shipment does not exceed license possession limits.
- ✓ Monitor the external surfaces of a labeled package according to specifications in the Table in 5.0.
- ✓ Open the outer package (following supplier's directions if provided) and remove packing slip. Open inner package to verify contents (compare requisition, packing slip and label on the bottle or other container). Check integrity of the final source container (e.g., inspecting for breakage of seals or vials, loss of liquid, discoloration of packaging material, high count rate on smear). Again, check that the shipment does not exceed license possession limits. If you find anything other than expected, stop and notify the RSO.

- ✓ Survey the packing material and packages for contamination before discarding. If contamination is found, treat as radioactive waste. If no contamination is found, obliterate the radiation labels prior to discarding in the regular trash.

- ✓ Maintain records of receipt, package survey, and wipe test results.

- ✓ Notify the RSO, the final carrier, and the New Hampshire Radiological Health Section when removable radioactive surface contamination or external radiation levels exceed the limits of He-P 4021 or 4022.

## 5.3 MATERIALS TRANSFER POLICY

### 5.3.1 INTERNAL TRANSFERS

Licensed materials that are to be transferred from one department or laboratory or AU's control to another should have prior approval from the RSO. A written transfer procedure has been developed by Radiation Safety to ensure that transfers are done in accordance with the conditions of the license. All transfers shall be done in a way that minimizes the probability of spillage or breakage. Double containers should be used, including suitable shielding, for such transfers. Contact Radiation Safety prior to any internal transfer of licensed material.

### 5.3.2 EXTERNAL TRANSFERS

Licensed material shall not be transferred or shipped from one institution to another without the approval of the RSO. Such transfers/shipments must be packaged and labeled in accordance with DOT, NRC, or U.S. Postal Service Regulations, whichever is applicable. In addition the receiving institution must be licensed for the material and willing to accept the liability associated with receipt and possession of the material. Contact Radiation Safety prior to any external transfer of licensed material.

### 5.3.3 GIFTS

On occasion, individuals may be offered to have donated licensed materials by other individuals as gifts (e.g., a retiring scientist donating his radioactive sources or samples). All such gifts of radioactive materials must be transferred to UNH and handled in accordance with Radiological Health Section and NRC requirements and the conditions of the license. In any case, the RSO should approve the gift prior to the transfer.

# 6.0 OCCUPATIONAL AND PUBLIC DOSES

## 6.1 DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

UNH does not allow access to its research facilities by members of the general public. In addition, UNH's use of radiolabeled materials is restricted to controlled areas (e.g. locked laboratory and classroom facilities). UNH operations will be conducted so that doses to individual members of the public will be within the regulatory limits shown in the following table.

| **Annual Dose Limits** | |
|---|---|
| *Individual Members of the Public*<br><br>Total Effective Dose Equivalent (TEDE) | Annual Limit<br><br>0.1 rem |
| **Notes:** | |
| 1. The "total effective dose equivalent" (TEDE) is defined as the sum of the "deep-dose equivalent" (for external exposures) and the "committed effective dose equivalent" (for internal exposures). | |

## 6.2 OCCUPATIONAL EXPOSURE CONTROL

Occupational exposures at UNH will be maintained within the parameters outlined in the following table. ALARA limits are established as a goal for occupational exposures.

All Radiation Workers should minimize the potential for radiation exposure by following prudent external and internal radiation protection principles. Radiation Workers will follow administrative controls designed to limit radiation exposures. Engineering controls should be used whenever practicable. Personal Protective Equipment (PPE) should be used to limit potential radiation exposures.

The principal exposure concern at UNH is related to the internalization of radioactive materials. Internalization occurs when radioactive materials enter the body via a route of entry. The primary routes of entry are:

1) Inhalation
2) Absorption
3) Ingestion
4) Injection or puncture

The procedures and policies in this RPP have been designed to mitigate the effective uptake of radioactive materials via one of these primary routes of entry.

| Occupational Dose Limits | | |
|---|---|---|
| *Occupationally Exposed Adults* | Annual Limit | ALARA Limit |
| Total Effective Dose Equivalent (TEDE) | 5 rems | 0.5 rem |
| Total Organ Dose Equivalent (TODE) (except lens of the eye) | 50 rems | 5 rem |
| Eye (Lens) Dose Equivalent (LDE) | 15 rems | 1.5 rem |
| *Declared Pregnant Woman* | 0.5 rem to embryo/fetus | 0.05 rem to embryo/fetus |

**Notes:**

1. The "total effective dose equivalent" (TEDE) is defined as the sum of the "deep-dose equivalent" (for external exposures) and the "committed effective dose equivalent" (for internal exposures).
2. The "total organ dose equivalent" (TODE) applies to the sum of the "deep-dose equivalent" and the "committed dose equivalent" to any individual organ or tissue.
3. In order to avoid confusion with the acronym for effective dose equivalent (EDE), the abbreviation LDE is also used to represent the eye (lens) dose equivalent.

## 6.3 DECLARED PREGNANT WORKERS

Declaration of pregnancy is optional and is at the sole decision of the Radiation Worker. Declared Pregnant Women must issue their declaration in writing to the RSO and include the estimated date of inception. Upon declaration, the worker's dose limitations will be as represented above and:

1) All Declared Pregnant Women (DPW) will receive general information relative to radiation and its potential effect on the fetus.

2) DPW will be given specific information and instruction regarding their specific work responsibilities and corresponding radiation safety issues.

3) The RSO, or designee, will schedule an appointment with all DPW to discuss the information in 1) and to determine an appropriate bioassay schedule.

## 6.4 PERSONNEL MONITORING

### 6.4.1 EXTERNAL MONITORING

External exposure monitoring (whole body) will be required for any Radiation Worker working with energetic radioactive materials (e.g. > 250 keV). Extremity monitoring will be required for any Radiation Worker employing more than one millicurie of energetic material (e.g. > 250 keV)

in any single manipulation. Global Dosimetry, or another licensed vendor, will be the dosimetry service provider.

### 6.4.2 INTERNAL MONITORING

At a minimum, UNH will conduct quarterly bioassays (urine samples) of all Radiation Workers conducting research under new protocols where the likelihood for an exposure exceeding 10% of the annual limit is anticipated, for one year as a means of quantifying internal exposure levels.

It is the practice of this program to provide bioassay monitoring capability to detect an intake potentially resulting in a committed effective dose equivalent of 100 mrem. This program recommends placing workers on a routine bioassay monitoring program if the 50-year committed effective dose equivalent from a single intake or multiple intakes in a single calendar year may exceed 100 mrem.

The ALI is a useful concept for bioassay planning purposes when acute intakes are considered or exposure may be limited to readily identified quantities or sources. Routine bioassay monitoring will be performed for an acute or chronic intake of activity corresponding to 2% of the ALI.

Baseline and ending work samples or measurements will be obtained for a worker whose work assignments will require or have required routine bioassay monitoring.

The frequency of bioassay measurements is dictated by two objectives. The first is to monitor the accumulation of radioactive material in the body from low-level chronic intakes. The second is to assure that significant acute depositions are detected so that appropriate corrections can be instituted in the working conditions.

Generally, quarterly measurements will be used as a minimum frequency, where applicable. Routine bioassay measurement periods longer than five effective half lives are also generally not recommended, because the potential deviation of individuals from assumed retention or excretion patterns can substantially affect doses associated with the program design.

Bioassays will be collected under the following situations:

1) At least quarterly for one year from all active Radiation Workers working under new protocols that may lead to an exposure greater than 10% of the annual occupational limit.

2) After an exposure event (potential exposure via an effective route of entry).

3) At the request of the RSO or Radiation Worker.

4) At frequencies determined by the RSO for any individual likely to receive greater than 10% of the allowable occupational exposure in any one year.

Any positive results detected above the minimum instrument detectable activity will be combined with any external exposure monitoring results for the individual(s) to derive the Total Effective Dose Equivalent (TEDE). Reports of bioassay results will be provided to Radiation Workers.

Bioassay may include either thyroid scans and/or urine samples dependent on the nuclide(s) involved. Thyroid scans will be performed on site at UNH. Urine samples will be analyzed by Clym Environmental Services, LLC (State of Maryland license MD-21-035-01), or another licensed vendor. Persons using or handling radioiodine in quantities exceeding those in Table I of NRC Regulatory Guide 8.20 are required to have a thyroid uptake determination. Thyroid uptake measurements may also be required when lower radioiodine activities are used or processed, depending on the form or compound, degree of airborne radioactivity control, frequency of use, nature of the research or clinical use, and other such variables. Current applicable regulatory guides including NRC Regulatory Guide 8.20 and 8.9 are used for evaluating specific situations. Intake Evaluation Level is established as 2% of the Annual Limit of Intake (ALI). An Intake Investigational Level is established as 10% of the ALI.

# 7.0 SAFE USE OF RADIONUCLIDES AND EMERGENCY PROCEDURES

## 7.1 GENERAL TOPICS FOR SAFE USE OF RADIOISOTOPES

Each laboratory or area where radioactive material is used or stored must establish protocols for the use of radioactive materials. Within these protocols, specific instructions are to be provided to the Radiation Worker regarding the safe completion of that protocol.

General instructions that should be applied at all times when working with radioactive materials include:

- Wear a laboratory coat or other protective clothing at all times in areas where licensed materials are used.
- Wear disposable gloves at all times when handling licensed materials.
- After each procedure or before leaving the area, monitor hands, shoes, and clothing for contamination in a low-background area.
- Do not eat, drink, smoke or apply cosmetics in any area where licensed material is stored or used.
- Do not store food, drink or personal effects in areas where licensed material is stored or used.
- Wear personnel monitoring devices, if required, at all times while in areas where licensed materials are used or stored.
- Dispose of radioactive waste only in designated, labeled and properly shielded receptacles.
- Never pipette by mouth.
- Store radioactive solutions in clearly labeled containers.
- Secure all licensed material when it is not under the constant surveillance and immediate control of the user(s).

### 7.1.1 CLASSIFICATION OF WORKPLACES (Adapted from International Labor Office *Guidelines for the Protection of Workers in Industry (Ionizing Radiations)* Occupational Safety and Health Series 62 ©International Labor Organization, 1989)

The RSC and/or RSO will use the following workplace classification method to determine the facilities and equipment necessary for approving radioactive material usage.

- In view of the extreme diversity of processes carried out with unsealed radioactive sources and the great variety of potential risks, working area and workshops should be classified according to the relative radiotoxicity of the radionuclides taking into account the nature of the operations and the total amount used.

- Specialized installations should be divided into three types of workplaces depending, to the extent practicable, on the factors referred to above and in accordance with Table 7.1 for radiotoxicity classification. The types of workplace are commonly referred to as:

  (a) Type I workplace or type C workplace;
  (b) Type II workplace or type B workplace;
  (c) Type III workplace or type A workplace.

- The activity limits for use of radionuclides in the various types of workplaces are given in Table 7.2.

- Workplaces of all three types should be:

  (a) reserved exclusively for work with radioactive substances and isolated from other workplaces as far as is practicable;
  (b) subject to classification according to the potential risks involved: normally areas where radioactive substances are used will be classified as controlled areas; however, areas where workers are not likely to receive more than three tenths of the dose limits may be either included in a controlled area or defined as supervised areas if this is duly justified and considered more convenient.

- A changing area may be provided at the entrances of areas where radioactive substances are prepared or used, in order to prevent contamination from being transported by persons to outside areas. The changing area may contain a foot barrier where practicable. Clean clothing (non-contaminated) should be left outside the barrier and protective clothing, equipment and containers for waste should be provided on the active side of the barrier.

- Washing facilities should be designed and set up appropriate to the level of radioactivity present in the workplace.

- Changing areas should contain monitoring and control equipment, appropriate to the levels of radioactive materials present, to monitor the hands, feet, shoes and clothing of workers leaving controlled or supervised areas. Additional check points should be established within controlled areas when necessary, depending on the type of work being carried out.

- Separate rooms should be assigned to different types of work when such work involves widely varying levels of activity, and in accordance with the classification of workplaces as given in this chapter.

- Counting apparatus should normally be placed in a separate room. The design should take into account, as far as practicable, the transfer of radioactive materials from one workplace to another, where necessary, without passing through the surrounding area.

#### 7.1.1.1 Type I Workplace

1) The design, construction and equipment of a Type I (or Type C) workplace should be similar to those of a good quality modern chemical laboratory.
2) Normal ventilation is usually sufficient, and could be complemented with continuous movement of air into a fume hood.

#### 7.1.1.2 Type II Workplace

1) A Type II (or Type B) workplace should be specifically designed, constructed and equipped for work with radioisotopes.
2) The levels of airborne activity should be kept As Low As Reasonably Achievable by the use of totally or partially ventilated fume hoods or glove boxes.
3) The workplace should have reduced air pressure relative to the surrounding areas. The ventilation exhaust should be via a fume hood. There should be a space for an absolute filter to be put between the fume hood and the ventilation duct allowing for easy change of the filter and for monitoring the negative pressure gradient. Special attention should be given to avoid the recirculation of air and the dispersion of contamination to other occupied areas.
4) The surfaces of the fume hood and the ventilation duct should be smooth and made of non-absorbent material that can withstand the chemicals normally used in the hood.
5) The speed of the air flow should be regular, without eddies, and should be such that there can be no escape of air from the fume hood into the workplace under typical operating conditions (i.e. the

opening of windows and doors and the suction of other fume hoods). This should be checked using smoke tests, etc. The gas, water and electrical outputs should be operated from outside the hood.

6) Fume hoods and glove boxes where "active" work is carried out should be properly marked with the radiation symbol and the appropriate explanatory text.
7) A waste bin with a foot-operated lid should be available for the collection of low activity waste. A carboy which could withstand the effects of various chemicals, etc. and the effects of radiation should be provided for the temporary retention of liquid waste. All waste containers should bear a radiation warning sign and appropriate verbiage.
8) Facilities for hand-washing should be foot or elbow operated.
9) A special area should be provided for the storage of radioactive substances.

#### 7.1.1.3 Type III Workplace

1) In addition to all requirements of a Type II workplace, a Type III (or Type A) workplace should be specifically designed, constructed and equipped for handling large quantities of radioactive material in accordance with the specifications and requirements of any applicable regulator.
2) Processes involving risks of air contamination should be carried out in completely enclosed glove boxes or hot cells under negative pressure and provided with filters and transfer boxes.
3) Radioactive substances should be stored only in a special room equipped with suitable shielding and ventilation, and in accordance with the provisions regarding waste storage.

**Table 7.1 Toxicity Classification of Radionuclides**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Very High Radiotoxicity** | | | | | | | | | |
| $^{205}$Pb | $^{225}$Ra | $^{228}$Th | $^{232}$U | $^{232}$Pu | $^{241}$Pu | $^{243}$Am | $^{244}$Cm | $^{248}$Cm | $^{251}$Cf |
| $^{208}$Po | $^{226}$Ra | $^{229}$Th | $^{233}$U | $^{238}$Pu | $^{242}$Pu | $^{240}$Cm | $^{245}$Cm | $^{248}$Cf | $^{252}$Cf |
| $^{210}$Pb | $^{228}$Ra | $^{230}$Th | $^{234}$U | $^{239}$Pu | $^{241}$Am | $^{242}$Cm | $^{246}$Cm | $^{249}$Cf | $^{254}$Cf |
| $^{210}$Po | $^{227}$Ac | $^{231}$Pa | $^{237}$Np | $^{240}$Pu | $^{242m}$Am | $^{243}$Cm | $^{247}$Cm | $^{250}$Cf | $^{254}$Es |
| $^{233}$Ra | $^{227}$Th | $^{230}$U | | | | | | | |
| **High Radiotoxicity** | | | | | | | | | |
| $^{22}$Na | $^{91}$Y | $^{115m}$Cd | $^{125}$I | $^{144}$Ce | $^{181}$Hf | $^{207}$Bi | $^{232}$Th | $^{242}$Am | $^{253}$Es |
| $^{36}$Cl | $^{93}$Zr | $^{114m}$In | $^{126}$I | $^{152}$Eu | $^{182}$Ta | $^{210}$Bi | Th Nat | $^{241}$Cm | $^{254m}$Es |
| $^{45}$Ca | $^{94}$Nb | $^{124}$Sb | $^{131}$I | $^{154}$Eu | $^{192}$Ir | $^{211}$At | $^{230}$Pa | $^{249}$Bk | $^{255}$Fm |
| $^{46}$Sc | $^{106}$Ru | $^{125}$Sb | $^{134}$Cs | $^{160}$Tb | $^{204}$Tl | $^{224}$Ra | $^{236}$U | $^{246}$Cf | $^{256}$Fm |
| $^{60}$Co | $^{110m}$Ag | $^{124}$I | $^{140}$Ba | $^{170}$Tm | $^{212}$Pb | $^{228}$Ac | $^{244}$Pu | $^{253}$Cf | |
| $^{90}$Sr | $^{111}$In | | | | | | | | |
| **Moderate Radiotoxicity** | | | | | | | | | |
| $^{7}$Be | $^{52}$Fe | $^{82}$Br | $^{97}$Zr | $^{105}$Ag | $^{134}$Te | $^{143}$Ce | $^{171}$Tm | $^{198}$Au | $^{237}$U |
| $^{14}$C | $^{55}$Fe | $^{74}$Kr | $^{90}$Nb | $^{111}$Ag | $^{120}$I | $^{142}$Pr | $^{175}$Yb | $^{199}$Au | $^{240}$U |
| $^{18}$F | $^{59}$Fe | $^{77}$Kr | $^{93m}$Nb | $^{109}$Cd | $^{123}$I | $^{143}$Pr | $^{177}$Lu | $^{197}$Hg | $^{239}$Np |
| $^{24}$Na | $^{55}$Co | $^{87}$Kr | $^{95}$Nb | $^{115}$Cd | $^{130}$I | $^{147}$Nd | $^{181}$W | $^{197m}$Hg | $^{240}$Np |
| $^{31}$Si | $^{56}$Co | $^{88}$Kr | $^{96}$Nb | $^{115m}$In | $^{132m}$I | $^{149}$Nd | $^{185}$W | $^{203}$Hg | $^{234}$Pu |
| $^{32}$P | $^{57}$Co | $^{86}$Rb | $^{90}$Mo | $^{113}$Sn | $^{133}$I | $^{147}$Pm | $^{187}$W | $^{200}$Tl | $^{237}$Pu |
| $^{33}$P | $^{58}$Co | $^{83}$Sr | $^{93}$Mo | $^{125}$Sn | $^{135}$I | $^{149}$Pm | $^{183}$Re | $^{201}$Tl | $^{245}$Pu |
| $^{35}$S | $^{63}$Ni | $^{85}$Sr | $^{99}$Mo | $^{122}$Sb | $^{135}$Xe | $^{151}$Sm | $^{186}$Re | $^{202}$Tl | $^{238}$Am |
| $^{38}$Cl | $^{65}$Ni | $^{89}$Sr | $^{96}$Tc | $^{121}$Te | $^{132}$Cs | $^{153}$Sm | $^{188}$Re | $^{203}$Pb | $^{240}$Am |
| $^{41}$Ar | $^{64}$Cu | $^{91}$Sr | $^{97m}$Tc | $^{121m}$Te | $^{136}$Cs | $^{152m}$Eu | $^{185}$Os | $^{206}$Bi | $^{244m}$Am |
| $^{42}$K | $^{65}$Zn | $^{92}$Sr | $^{97}$Tc | $^{123m}$Te | $^{137}$Cs | $^{155}$Eu | $^{191}$Os | $^{212}$Bi | $^{244}$Am |
| $^{43}$K | $^{69m}$Zn | $^{90}$Y | $^{99}$Tc | $^{125m}$Te | $^{131}$Ba | $^{153}$Gd | $^{193}$Os | $^{220}$Rn | $^{238}$Cm |
| $^{47}$Ca | $^{72}$Ga | $^{92}$Y | $^{97}$Ru | $^{127m}$Te | $^{140}$La | $^{159}$Gd | $^{190}$Ir | $^{222}$Rn | $^{250}$Bk |
| $^{47}$Sc | $^{73}$As | $^{93}$Y | $^{103}$Ru | $^{129m}$Te | $^{134}$Ce | $^{165}$Dy | $^{194}$Ir | $^{226}$Th | $^{244}$Cf |
| $^{48}$Sc | $^{74}$As | $^{86}$Zr | $^{105}$Ru | $^{131}$Te | $^{135}$Ce | $^{166}$Dy | $^{191}$Pt | $^{231}$Th | $^{254}$Fm |
| $^{48}$V | $^{76}$As | $^{88}$Zr | $^{105}$Rh | $^{131m}$Te | $^{137m}$Ce | $^{166}$Ho | $^{193}$Pt | $^{234}$Th | |
| $^{51}$Cr | $^{77}$As | $^{89}$Zr | $^{103}$Pd | $^{132}$Te | $^{139}$Ce | $^{169}$Er | $^{197}$Pt | $^{233}$Pa | |
| $^{52}$Mn | $^{75}$Se | $^{95}$Zr | $^{109}$Pd | $^{133m}$Te | $^{141}$Ce | $^{171}$Er | $^{196}$Au | $^{231}$U | |
| $^{54}$Mn | | | | | | | | | |
| **Low Radiotoxicity** | | | | | | | | | |
| $^{3}$H | $^{60m}$Co | $^{81}$Kr | $^{91m}$Y | $^{99m}$Tc | $^{120m}$I | $^{127}$Cs | $^{138}$Cs | $^{207}$Po | $^{243}$Pu |
| $^{15}$O | $^{61}$Co | $^{83m}$Kr | $^{88}$Nb | $^{103m}$Rh | $^{121}$I | $^{129}$Cs | $^{137}$Ce | $^{227}$Ra | $^{237}$Am |
| $^{37}$Ar | $^{62m}$Co | $^{85m}$Kr | $^{89}$Nb | $^{113m}$In | $^{128}$I | $^{130}$Cs | $^{191m}$Os | $^{235}$U | $^{239}$Am |
| $^{51}$Mn | $^{59}$Ni | $^{85}$Kr | $^{97}$Nb | $^{116}$Te | $^{129}$I | $^{131}$Cs | $^{193m}$Pt | $^{238}$U | $^{245}$Am |
| $^{52m}$Mn | $^{69}$Zn | $^{80}$Sr | $^{98}$Nb | $^{123}$Te | $^{134}$I | $^{134m}$Cs | $^{197m}$Pt | $^{239}$U | $^{246m}$Am |
| $^{53}$Mn | $^{71}$Ge | $^{81}$Sr | $^{93m}$Mo | $^{127}$Te | $^{131m}$Xe | $^{135}$Cs | $^{203}$Po | U Nat | $^{246}$Am |
| $^{56}$Mn | $^{76}$Kr | $^{85m}$Sr | $^{101}$Mo | $^{129}$Te | $^{133}$Xe | $^{135m}$Cs | $^{205}$Po | $^{235}$Pu | $^{249}$Cm |
| $^{58m}$Co | $^{79}$Kr | $^{87m}$Sr | $^{96m}$Tc | $^{133}$Te | $^{125}$Cs | | | | |

**Table 7.2 Activity Limits for Use of Radionuclides in Various Types of Workplace**

| Radionuclide Group | Workplace Classification | | |
|---|---|---|---|
| | **Type I** | **Type II** | **Type III** |
| Very High | ≤ 0.0135 mCi | 0.0135 TO 13.5 mCi | ≥ 13.5 mCi |
| High | ≤ 0.135 mCi | 0.135 TO 135.1 mCi | ≥ 135.1 mCi |
| Moderate | ≤ 1.35 mCi | 1.35 TO 1,351.4 mCi | ≥ 1,351.4 mCi |
| Low | ≤ 13.5 mCi | 13.5 TO 13,513.5 mCi | ≥13,513.5 mCi |

This Table provides, as precisely as the complexity of the subject will allow, a basis for assessing the type of workplace required for normal operations. According to the nature of the operations, the following modifying factors should be applied:

| **Operation** | **Modifying Factor** |
|---|---|
| Storage (stock solutions) | **X 100** |
| Very simple wet operations | **X 10** |
| Normal operations | **X 1** |
| Complex wet operations with risk of spills and simple dry operations | **X 0.1** |
| Dry and dusty operations | **X 0.01** |

**Table 7.3 Hazard Index (HI)** (Hickey, 1991 adapted from *The Health Physics and Radiological Health Handbook*, Schleien, 1998)

The HI may be used to assess workplace air monitoring requirements and the potential intake of workers. Using this formula an HI of 100 represents a potential intake of 1 ALI.

$$HI = \frac{Q \times 10\text{-}6 \times R \times F}{ALI \times C} \times 100$$

**where:**

F = other modifying factors (For instance: added dispersibility due to added energy, e.g. chemistry, grinding, adjustments due to less than annual work duration, etc.)

Q = average annual activity used
ALI = annual limit of intake
C = confinement factor (see below)
R = Release Fraction (see below)

***RELEASE FRACTIONS***

| **Condition** | **Factor** |
|---|---|
| Gases or volatile material | 1 |
| Nonvolatile powders (beta-gamma) | 0.01 |
| Nonvolatile powders (alpha) | 0.001 |
| Solid, e.g. metals | 0.001 |
| Liquid | 0.01 |
| Surface Contamination (beta-gamma) | 0.001 |
| Surface Contamination (alpha) | 0.0001 |
| Encapsulated material | 0 |

***CONFINEMENT FACTORS***

| **Condition** | **Factor** |
|---|---|
| Glovebox | 100 |
| Hood (well ventilated) | 10 |
| Open bench, normal ventilation | 1 |
| Non-routine or special jobs where ventilation is unknown | 0.01 |

## 7.2 GENERAL SAFETY PROCEDURES TO HANDLE SPILLS

Emergency phone numbers for Radiation Safety staff members are posted conspicuously in areas of use, so that they are readily available to workers in case of emergencies. UNH has area emergency equipment readily available for handling spills. Commonly available spill response materials include the following:

— Disposable gloves.
— Disposable lab coats.
— Disposable shoe covers.
— Absorbent materials.
— Plastic containment bags.
— "Radioactive Material" labeling tape.
— Marking pen.
— Decontamination solution.
— Box of Wipes.
— Instructions for "Emergency Procedures".
— Hazard communication signage.
— Appropriate survey instruments including batteries (for survey meters).

## 7.3 MINOR SPILLS OF LIQUIDS AND SOLIDS

Instructions to Workers:

- Stop the spill and prevent the spread of contamination by covering the spill with absorbent paper. (Paper should be dampened if solids are spilled).
- Warn others in the area that a spill has occurred.
- Isolate the area so as not to spread contamination. Use radiation symbol tape or ribbon if possible; use any physical barrier like chairs or tables if radiation symbol tape is not available.
- Monitor for skin and clothing contamination.
- Survey and cleanup the contaminated area. Do not forget to wear your dosimeter (if necessary) or the proper protective equipment: gloves, laboratory coat, eye protection and disposable shoe coverings (if necessary) before attempting to clean the spill. Mark the perimeter of the spill and isolated spots. Thoroughly clean by wiping the contamination with absorbent paper, working from the perimeter towards the center of the spill.
- Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Put contaminated gloves and any other contaminated disposable material in the bag.
- Once finished with the decontamination, 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 recheck hands, face, clothing, and shoes for contamination.
- Report the incident to the Radiation Safety Officer (RSO) promptly.
- 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, provision of requested bioassay samples, following decontamination techniques, surveys, requested documentation).

Reminders to RSO:

- Follow up on the decontamination activities and document the results.
- As appropriate, determine cause and corrective actions needed; consider bioassays if licensed material may have been ingested, inhaled, and/or absorbed through the skin.
- If necessary, notify the State of New Hampshire.

## 7.4 MAJOR SPILLS OF LIQUIDS AND SOLIDS

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

(1) Radioactive material greater than or equal to one millicurie is involved;
(2) Radioactive liquids greater than one liter are involved;
(3) Any personal contamination;
(4) Any contamination in unrestricted areas;
(5) Multiple findings of contamination within a restricted area.

Instructions to 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 washing 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, provision of requested bioassay samples).
- Follow the instructions of the RSO/Radiation Safety staff (e.g., decontamination techniques, surveys, provision of bioassay samples, requested documentation).

Reminders to RSO:

- Confirm decontamination of personnel. If decontamination of personnel was not fully successful, 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 decontamination activities and document the results. Documentation should include location of surveys and decontamination results.
- Determine cause and corrective actions needed; consider need for bioassays if licensed material may have been ingested, inhaled, and/or absorbed through the skin.
- If necessary, notify the State of New Hampshire.

## 7.5 INCIDENTS INVOLVING RADIOACTIVE DUSTS, MISTS, FUMES, ORGANIC VAPORS, AND GASES

Instructions to Workers:

- Notify all personnel to vacate the room immediately.
- Shut down ventilation system, if appropriate, to prevent the spread of contamination throughout system and other parts of facility.
- Vacate the room. Seal the area, if possible.
- Notify the Radiation Safety Officer (RSO) immediately.
- Ensure that all access doors to the area are closed and posted with radiation warning signs, or post guards (trained) at all access doors to prevent accidental opening of the doors or entry to the area.
- Survey all persons who could have possibly been contaminated. Decontaminate as directed by the RSO.
- Promptly report suspected inhalations and ingestions of licensed material to the RSO.
- Decontaminate the area only when advised and/or supervised by the RSO.

- Allow no one to return to work in the area unless approved by the RSO.
- Cooperate with the RSO/Radiation Safety staff (e.g., investigation of root cause, provision of requested bioassay samples).
- Follow the instructions of the RSO/Radiation Safety staff (e.g., decontamination techniques, surveys, provision and collection of bioassay samples, and requested documentation).

Reminders to RSO:

- Supervise decontamination activities.
- Perform air sample surveys in the area before permitting resumption of work with licensed materials
- Provide written directions to potentially contaminated individuals about providing and collecting urine, breath, blood, or fecal samples, etc.
- Consider need for medical exam and/or whole body count before permitting involved individuals to return to work with licensed material.
- Determine cause and corrective actions needed; consider need for bioassays if licensed material may have been ingested, inhaled, and/or absorbed through the skin. Document incident.
- If necessary, notify the State of New Hampshire.

## 7.6 MINOR FIRES

Instructions to Workers:

- Immediately attempt to put out the fire by approved methods (i.e., fire extinguisher) if other fire hazards or radiation hazards are not present.
- Notify all persons present to vacate the area and have one individual immediately call the Radiation Safety Officer (RSO) and fire department (as instructed by RSO).
- Once the fire is out, isolate the area to prevent the spread of possible contamination.
- Survey all persons involved in combating the fire for possible contamination.
- Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water, then washing with a mild soap.
- In consultation with the RSO, determine a plan of decontamination and the types of protective devices and survey equipment that will be necessary to decontaminate the area.
- Allow no one to return to work in the area unless approved by the RSO.

- Cooperate with the RSO/Radiation Safety staff (e.g., investigation of root cause, provision of requested bioassay samples).
- Follow the instructions of the RSO/Radiation Safety staff (e.g., decontamination techniques, surveys, provision of bioassay samples, and requested documentation).

Reminders to RSO:

- Supervise decontamination activities.
- If decontamination of personnel was not fully successful, 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.
- Consult with fire safety officials to assure that there are no other possibilities of another fire starting.
- Determine cause and corrective actions needed; consider need for bioassays if licensed material may have been ingested, inhaled, and/or absorbed through the skin. Document the incident.
- If necessary, notify the State of New Hampshire.

## 7.7 FIRES, EXPLOSIONS, OR MAJOR EMERGENCIES

Instructions to Workers:

- Notify all persons in the area to leave immediately.
- Call 911.
- Notify the Radiation Safety Officer and other facility safety personnel.
- Upon arrival of firefighters, inform them where radioactive materials are stored or where radioisotopes were being used. Inform them of the present location of the licensed material and the best possible entrance route to the radiation area, as well as any precautions to avoid exposure or risk of creating radioactive contamination by use of high pressure water, etc.
- Cooperate with the RSO/Radiation Safety staff (e.g., investigation of root cause, provision of requested bioassay samples).
- Allow no one to return to work in the area unless approved by the RSO.
- Follow the instructions of the RSO/Radiation Safety staff (e.g., decontamination techniques, surveys, provision of bioassay samples, and requested documentation).

Reminders to RSO:

- Coordinate activities with Facilities Management, Environmental Health & Safety, and with local fire department.

- Consult with the firefighting personnel and set up a controlled area where the firefighters can be surveyed for contamination of their protective clothing and equipment after the fire is extinguished.
- Once the fire is extinguished, do not allow the firefighters to enter the radiation area until a thorough evaluation and survey are performed to determine the extent of the damage to the licensed material use and storage areas.
- Perform thorough contamination surveys of the firefighters and their equipment before they leave the controlled area and decontaminate, if necessary.
- Supervise decontamination activities.
- Consider bioassays if licensed material may have been ingested, inhaled, and/or absorbed through the skin. Document the incident.
- If necessary, notify the State of New Hampshire.

## 7.8 HIGH ENERGY BETA USAGE

Special consideration must be given to protocols that employ over one millicurie of energetic beta emitters (> 1.0 MeV, e.g. Phosporus-32 ($^{32}P$)). Individuals performing such work should adhere to the following:

1. Use low density shielding (e.g. plexi-glass or Lucite) at a minimum thickness of 3/8 inch to minimize exposure.
2. Follow the survey requirements in 8.0. This survey should include both a portable meter survey and wipe test survey for contamination.
3. Follow the external monitoring requirements in 6.4 and use extremity monitors.
4. Conduct a "dry run" of unfamiliar procedures in order to minimize unexpected complications. Consult with the Radiation Safety Officer regarding new procedures or have the RSO present when conducting these "dry runs."
5. Eye protection (safety glasses) is required for any procedure involving 10 millicuries or more of a high-energy beta emitter.

## 7.9 RADIOIODINE MANIPULATIONS

Special consideration must be given to unbound forms of radioiodine (e.g. $^{125}I$ or $^{131}I$). Individuals working with radioiodine in unbound form must adhere to the following additional requirements:

1. All unbound radioiodine will be stored in a leaded acrylic box, or equivalent, within a designated chemical fume hood and used in a designated chemical fume hood.

2. All iodination procedures will be performed in the iodination cabinet within the designated chemical fume hood.

3. All solid waste generated from this procedure will be stored in the proper waste receptacle in the Iodination Lab.

4. All liquid wastes will be stored behind lead shielding in the designated chemical fume hood.

5. All radioactive waste generated from iodination procedures must be in bound form.

6. All iodination procedures must be reviewed and approved by the Radiation Safety Committee prior to commencement of work.

7. Users of unbound radioiodine must report for baseline bioassay monitoring (thyroid scan) prior to work with the material. Post-procedure bioassays will also be performed, as directed by the RSO.

8. The User shall restrict access to the Iodination Lab until completion of the experiment and post-work surveys.

9. Air sampling in the breathing zone will be conducted before, during, and after work with volatile radioiodine using a charcoal trap attached to an air sampling pump. Effluent sampling will also be conducted on exhaust from the iodination cabinet.

10. Extremity dosimeters are required for any experiment involving one millicurie or greater of $^{125}I$ or $^{131}I$.

## 8.0 SURVEYS AND MONITORING

Areas under radiological control will be surveyed to evaluate radiation levels, characterize workplace conditions and to identify potential radiological hazards. Radiological instruments shall be used only to measure the radiation for which their calibrations are valid. Wipe samples will be analyzed on site utilizing a liquid scintillation counter using liquid scintillation counting techniques.

## 8.1 TRAINING

Before allowing an individual to perform surveys, the Radiation Safety Officer (RSO) will ensure that he or she has sufficient training and experience to perform surveys independently. Academic training may be in the form of lecture, videotape, or self-study and will cover the following subject areas:

- Principles and practices of radiation protection.
- Radioactivity measurements, monitoring techniques, and using instruments.
- Mathematics and calculations basic for using and measuring radioactivity.
- Biological effects of radiation.
- Appropriate on-the-job training consists of the following:
- Observing authorized personnel using survey equipment, collecting samples, and analyzing samples.
- Using survey equipment, collecting samples, and analyzing samples under the supervision and in the physical presence of an individual authorized to perform surveys.

## 8.2 FACILITIES AND EQUIPMENT

As a rule, the following guidelines will be adhered to during all surveys:

- To ensure achieving the required sensitivity of measurements, survey samples will be analyzed in a low-background area.

- A gamma counter system with a single or multi-channel analyzer can be used to count samples containing gamma-emitters (e.g., $^{125}I$, $^{51}Cr$).

- A liquid scintillation or gas-flow proportional counting system can be used to count samples containing alpha-emitters, beta-emitters, and gamma-emitters (if efficiency is great enough to achieve the required sensitivity for measurements).

## 8.3 AMBIENT RADIATION LEVEL SURVEYS

The frequency of ambient surveys depends on the quantity and use of radioactive materials, as well as the specific protective facilities, equipment, and procedures that are designed to protect the worker and members of the public from external exposure to radiation. While the regulations do not specify a specific survey frequency, UNH is required to ensure that the dose rate limits are not exceeded. The RSO/Radiation Safety staff will inspect the laboratories of Authorized Users quarterly to monitor the lab's radiation protection program.

- Dose-rate surveys, at a minimum, should be performed in locations where workers are exposed to radiation levels that might result in radiation doses in excess of 10% of the occupational dose limits or where an individual is working in a dose rate of 0.025 mSv (2.5 mrem/hr) or more (50 mSv/year divided by 2,000 hr/year).

- He-P 4020.13 requires that the total effective dose equivalent to an individual member of the public from the licensed operation does not exceed 1 mSv (0.1 rem) in a year and the dose in any unrestricted area from external sources does not exceed 0.02 mSv (2 mrem) in any one hour.

The survey will include an assessment of procedural compliance, area contamination and ambient radiation levels. Radiation exposure rates and removable contamination levels will be measured and record keeping systems reviewed during the surveys. These surveys are presently documented on the UNH Radiation Safety Audit Checklist (see Attachment Four). The RSO prepares a survey report that lists all significant findings to the AU and includes a timetable for correction. The AU must respond to any items of non-compliance to the RSO within 30 days of receipt of the survey report. If satisfactory correction is not achieved in a timely manner, the AU's radioactive material ordering privileges are suspended. The Radiation Safety Committee reviews all radiation survey reports. Any inconsistencies brought to the attention of the RSC must be resolved before the next quarterly meeting of the committee. Failure of the AU to resolve these inconsistencies could result in the temporary or permanent suspension of his/her permit to use radioactive material. All records are maintained in an electronic computer database as well as a paper copy.

## 8.4 CONTAMINATION SURVEYS

UNH contamination surveys will be sufficient to identify areas of contamination that might result in doses to workers or to the public. Combined removable and fixed contamination should be surveyed using appropriate radiation detection equipment. Removable contamination can be detected and measured through a wipe test of the surface, which is counted in an appropriate counting instrument,

such as a liquid scintillation counter, a sodium iodide or germanium gamma counter, or a proportional alpha/beta counter.

Contamination surveys should be performed:

- To evaluate radioactive contamination that could be present on surfaces of floors, walls, laboratory furniture, and equipment.
- After any spill or contamination event.
- When procedures or processes have changed.
- To evaluate the potential contamination of users and the immediate work area, at the end of the day or prior to leaving the area of use, when licensed material is used.
- In unrestricted areas at frequencies consistent with the types and quantities of materials in use, but generally not less frequently than quarterly.
- In areas adjacent to restricted areas and in all areas through which licensed materials are transferred and temporarily stored before shipment.

### 8.4.1 CONTAMINATION SURVEY FREQUENCY

Personnel should survey for contamination in locations where individuals are working with an unsealed form of radioactive material. These surveys should be done at a frequency appropriate to the types and quantities of radioactive materials in use. If the activity used is greater than or equal to the smallest Annual Limit on Intake (ALI) (for either inhalation or ingestion) as identified in He-P 4090.1, then documented surveys should be performed at least daily in accordance with He-P 4021 and 4022. Formal Authorized User survey schedules will be established by the RSO and approved by the RSC. Unless otherwise instructed, the typical schedule will be to survey after each use and perform a weekly survey and wipe test, with written documentation.

The following table contains suggested contamination survey frequencies based on ALIs. The suggested frequency of surveys is based upon the amount of licensed material "in use" at any one time at any particular location. If licensed material has not been used for a period of time greater than the required survey frequency, then it is considered to be "not in use."

| **Contamination Survey Frequency** | | | |
|---|---|---|---|
| | < 0.1 ALI | > 0.1 ALI < 1.0 | > 1.0 ALI |
| In Use | Monthly | Weekly | Daily |
| Not in Use | Every 6 Months | | |

## 8.4.2 CONTAMINATION IN UNRESTRICTED AREAS

Contamination found in unrestricted areas should be immediately decontaminated to background levels. When it is not possible to get to background levels, UNH will ensure that the amounts do not exceed the contamination levels listed in the following table.

| Acceptable Surface Contamination Levels for Equipment | | | |
|---|---|---|---|
| Nuclide[a] | Average[b,c] | Maximum[b,d] | Removable[b,e] |
| $^{125}I$ | 1.7Bq/100cm$^2$ (100dpm/100cm$^2$) | 5.0Bq/100cm$^2$ (300dpm/100cm$^2$) | 0.3Bq/100cm$^2$ (20dpm/100cm$^2$) |
| $^{131}I$ | 16.7Bq/100cm$^2$ (1,000dpm/100cm$^2$) | 50.0Bq/100cm$^2$ (3,000dpm/100cm$^2$) | 3.3Bq/100cm$^2$ (200dpm/100cm$^2$) |
| Beta-gamma emitters except those noted above | 83.3Bq/100cm$^2$ (5,000dpm/100cm$^2$) | 250Bq/100cm$^2$ (15,000dpm/100cm$^2$) | 16.7Bq/100cm$^2$ (1,000dpm/100cm$^2$) |

Note: 1 Bq = 1 Disintegration per second

a Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

b As used in this table, dpm (disintegration per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

c Measurements of average contaminant 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.

d The maximum contamination level applies to an area of not more than 100 cm$^2$.

e The amount of removable radioactive material per 100 cm$^2$ of surface area should be determined by wiping that area with 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 proportionally and the entire surface should be wiped.

When equipment or facilities that are potentially contaminated are to be released for unrestricted use, the above table provides the maximum acceptable residual levels for equipment and the table below provides action limits and ALARA goals for removable contamination control. To the extent practicable, it is appropriate to decontaminate to below these levels. Surface contamination surveys should be conducted for both removable and fixed contamination before these facilities or equipment

are released from restricted to unrestricted use, to ensure that they meet these limits.

A standardized method for wipe testing of a relatively uniform area should be used to aid in comparing contamination at different times and places. A wipe taken from an area of about 100 $cm^2$ is acceptable to indicate levels of removable contamination.

| **Action and ALARA Limits for Removable Surface Contamination Levels** | | |
|---|---|---|
| *Nuclide* | *Action Level* | *ALARA Goal* |
| $^{125}I$ | 0.3Bq/100$cm^2$ (20dpm/100$cm^2$) | 0.3Bq/100$cm^2$ (20dpm/100$cm^2$) |
| $^{131}I$ | 1.7Bq/100$cm^2$ (100dpm/100$cm^2$) | 3.3Bq/100$cm^2$ (200dpm/100$cm^2$) |
| Beta-gamma emitters except those noted above | 1.7Bq/100$cm^2$ (100dpm/100$cm^2$) | 3.67Bq/100$cm^2$ (220dpm/100$cm^2$) |

## 8.5 SURVEY RECORD REQUIREMENTS

Each survey record should include the following, at a minimum:

- A diagram or representation of the area surveyed.
- A list of items and equipment surveyed.
- Specific locations on the survey diagram where wipe test was taken.
- Ambient radiation levels with appropriate units.
- Contamination levels with appropriate units.
- Make and model number of instruments used.
- Background levels.
- Name of the person making the evaluation and recording the results and date.

Surveyors should record contamination levels observed and procedures followed for incidents involving contamination of individuals. The record should include names of individuals involved, description of work activities, calculated dose, probable causes (including root causes), steps taken to reduce future incidents of contamination, times and dates, and the surveyor's signature.

Records of surveys will be maintained in the Office of Environmental Health and Safety or in the responsible department.

## 8.6 AIR MONITORING IN THE WORKPLACE

Air sampling can be used to do the following:

- Determine whether the confinement of radioactive materials is effective.
- Measure airborne radioactive material concentrations in the workplace.
- Estimate worker intakes of radioactive material.
- Determine posting requirements.
- Determine what protective equipment and measures are appropriate.
- Warn of significantly elevated levels of airborne radioactive materials.

If bioassay measurements are used to determine worker doses of record, air sampling may be used to determine time of intake and to determine which workers should have bioassay measurements. The use of engineering controls and a good air sampling program can eliminate need for bioassays.

### 8.6.1 AIRBORNE EFFLUENT RELEASE MONITORING

When practicable, airborne radioactive effluents should be released from monitored release points (e.g., monitored stacks, discharges, vents) to provide accurate measurements to estimate public exposure. UNH will verify the performance of effluent monitoring systems by regular calibration (at least annually) to ensure their reliability. Nuclear Regulatory Commission Regulatory Guide 4.20, "Constraints on Release of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors," dated December 1996, provides guidance on methods acceptable (calculation or COMPLY code) to NRC for compliance with the constraint on air emissions to the environment. Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities," dated July 1993, provides guidance on designing an acceptable program for establishing and maintaining ALARA levels for gaseous and liquid effluents at materials facilities.

For release points for which monitoring is not practicable, UNH will estimate the magnitude of the unmonitored effluents. These unmonitored releases will occur anytime unsealed material is handled outside a fume hood or other device that will control the releases. UNH will include these estimates when demonstrating compliance with dose limits and ALARA goals. Unmonitored releases may be estimated based on the quantity of material used in these areas, the number of procedures performed, or other

appropriate methods. The unmonitored effluents should not exceed 30% of the total estimated effluent releases or 10% of the permissible air effluent concentrations found on column 1 of Table 2 in 10 CFR Part 20, Appendix B, whichever is greater. Effluent monitoring systems should be designed in accordance with ANSI/HPS N13.1-1999, "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities," and ANSI N42.18, "Specification and Performance of On-site Instrumentation for Continuously Monitoring Radioactive Effluents."

## 8.7 LIQUID EFFLUENT RELEASE MONITORING

UNH will evaluate the concentrations of radioactive material in water that is released to the environment and to the sanitary sewer. UNH will document that these releases meet the limits in He-P 4021. The topic of sanitary sewerage releases is more fully discussed in the section on Waste Management.

## 8.8 BIOASSAY MONITORING

Bioassay monitoring will be conducted by UNH in accordance with the schedules outlined in Section 6 and with the following guidelines.

### 8.8.1 FREQUENCY OF REQUIRED BIOASSAY MEASUREMENTS

Determining the appropriate frequency of routine bioassay measurements depends upon the exposure potential, the physical and chemical characteristics of the radioactive material, and the route of entry to the body. Consider the following elements:

- Potential exposure of the individual.
- Retention and excretion characteristics of the radionuclides.
- Sensitivity of the measurement technique.
- Acceptable uncertainty in the estimate of intake and committed dose equivalent.

Bioassay measurements used for demonstrating compliance with the occupational dose limits should be conducted often enough to identify and quantify potential exposures and resultant intakes that, during any year, are likely to collectively exceed 0.1 times the ALI. The 10% ALI criterion is consistent with He-P 4020, which requires licensees to monitor intakes and assess occupational doses for exposed individuals who are likely to exceed 10 percent of the applicable limit (i.e., intakes likely to exceed 0.1 ALI for adults).

Separate categories of bioassay measurements, routine measurements and special measurements further determine the frequency and scope of measurements.

### 8.8.2 ROUTINE MEASUREMENTS

Routine measurements include baseline measurements, periodic measurements, and termination measurements. These measurements should be conducted to confirm that appropriate controls exist and to assess dose. The method of bioassay selected (for example, whole body counting, urinalysis, etc) and the samples collected will vary according to the radionuclide and the compound to which it is attached. Sample collection procedures should be developed to ensure that appropriate types, sizes, and numbers of samples are collected that will provide appropriate physiological information for the dose assessment.

An individual's baseline measurement of radioactive material within the body should be conducted before beginning work that involves exposure to radiation or radioactive materials for which monitoring is required. In addition to the baseline measurements, periodic bioassay measurements should be performed. The frequency of periodic measurements should be based on the likelihood of significant exposure of the individual. In determining the worker's likely exposure, consider such information as the worker's access, work practices, measured levels of airborne radioactive material, and exposure time. Periodic measurements should be made when the cumulative exposure to airborne radioactivity is > 0.02 ALI (40 DAC hours) since the most recent bioassay measurement. Noble gases and airborne particulates with a radioactive half-life of less than 2 hours should be excluded from the evaluation, since external exposure generally controls these radionuclides.

At a minimum, periodic measurements should be conducted annually. Periodic measurements provide additional information on any long-term accumulation and retention of radioactive material in the body, especially for exposures to concentrations of airborne radioactive material below monitoring thresholds. When an individual is no longer subject to the bioassay program, because of change in employment status, termination bioassay measurement should be made, when practicable, to ensure that any unknown intakes are quantified.

### 8.8.3 SPECIAL MONITORING

Because of uncertainty in the time of intakes and the absence of other data related to the exposure (e.g., physical and chemical forms, exposure duration), correlating positive results to actual intakes for routine measurements can sometimes be difficult. Abnormal and inadvertent

intakes from situations such as a failed respiratory protective device, inadequate engineering controls, inadvertent ingestion, contamination of a wound, or skin absorption, should be evaluated on a case-by-case basis. When determining whether potential intakes should be evaluated, consider the following circumstances:

- The presence of unusually high levels of facial and/or nasal contamination.
- Entry into airborne radioactivity areas without appropriate exposure controls.
- Operational events with a reasonable likelihood that a worker was exposed to unknown quantities of airborne radioactive material (e.g., loss of system or container integrity).
- Known or suspected incidents of a worker ingesting radioactive material.
- Incidents that result in contamination of wounds or other skin absorption.
- Evidence of damage to or failure of a respiratory protective device.

## 9.0 LEAK TEST PROCEDURES

This section outlines the leak test procedures and sample calculations for determining activity on a wipe test sample.

## 9.1 FREQUENCY FOR CONDUCTING LEAK TESTS OF SEALED SOURCES

Leak tests will be conducted every three months for each alpha emitting source requiring such a test. Leak tests will be conducted every six months for each non-alpha emitting source requiring such a test.

## 9.2 PROCEDURE FOR PERFORMING LEAK TESTING AND ANALYSIS

For each source to be tested, list identifying information such as manufacturer, model number, serial number, radionuclides, and activity.

- If available, use a survey meter to monitor exposure.
- Prepare a separate wipe sample (e.g., cotton swab or filter paper) for each source.
- Number each wipe to correlate with identifying information for each source.
- Wipe the most accessible area (but not directly from the surface of a source) where contamination would accumulate if the sealed source were leaking.
- Select an instrument that is sensitive enough to detect 185 becquerels (0.005 microcurie) of the radionuclides and ensure that its calibration is current.
- Using the selected instrument, count and record background count rate.
- Calculate efficiency.

  For example:

  $$\frac{\text{(cpm from std) - (cpm from bkg)}}{\text{activity of std in Bq}} = \text{efficiency in cpm/Bq}$$

  where: cpm = counts per minute
  std = standard
  bkg = background
  Bq = becquerel

- Count each wipe sample; determine net count rate.
- For each sample, calculate and record estimated activity in becquerels (or microcuries).
  For example:

  $$\frac{\text{(cpm from wipe sample) - (cpm from bkg)}}{\text{efficiency in cpm/Bq}} = \text{Bq on wipe sample}$$

- Sign and date the list of sources, data and calculations. Retain records for 5 years (He-P 4001.05).
- If the wipe test activity is 185 Bq (0.005 microcurie) or greater, notify the RSO, so that the source can be withdrawn from use and disposed of properly. Also notify State of New Hampshire.

## 9.3 LEAK TEST PERFORMANCE

UNH will use Clym Environmental Services, LLC, or another licensed vendor, to analyze all leak tests. The RSO conducts the required physical inventory and leak testing. All beta/gamma and neutron sealed sources (greater than 100 microcuries) will be tested for leakage and inventoried at intervals not to exceed six months. All sealed sources (greater than 10 microcuries) designed for the purpose of emitting alpha particles will be tested at intervals not to exceed three months. Ni-63 foil sources (greater than 100 microcuries) will be tested at intervals not to exceed six months. Results are maintained in an electronic computer database and in paper copy (the original leak check certificate received from the licensed vendor). The electronic computer database flags those sealed sources due for leak-testing. In addition, the outside vendor that performs the leak test analysis also sends the RSO a reminder notice when sealed sources are due for leak testing.

The RSO has the responsibility for maintaining a comprehensive inventory of all licensed radioactive materials. Please reference RPP section 1.3.2. Inventories of all sealed sources are maintained in an electronic computer database by the RSO in OEHS. The inventory lists the Authorized User, nuclide, half-life, decay, location and description. The databases also track the licensed possession limits of each Authorized User and ensure that the licensed possession limits for the institution are not exceeded and that the material can be accounted for. All new sealed sources are ordered, received and delivered by the RSO. The RSO will enter the new source into the electronic inventory database. Any transfer of a sealed source must have the written approval of the RSO. Each Authorized User is responsible for maintaining their individual sealed source inventory as well.

## 10.0 TRANSPORTATION

UNH will comply with all local, state and federal regulations regarding the transportation of radioactive materials. The major areas in the DOT regulations that are most relevant for transportation of licensed material shipped as Type A quantities are as follows:

- Hazardous Materials Table, 49 CFR 172.101, App. A, list of hazardous substances and reportable quantities (RQ), Table 2: Radionuclides.

- Shipping Papers 49 CFR 172.200-204: General entries, description, additional description requirements, shipper's certification.

- Package Markings 49 CFR 172.300, 49 CFR 172.301, 49 CFR 172.303, 49 CFR 172.304, 49 CFR 172.310, 49 CFR 172.324: General marking requirements for non-bulk packagings, prohibited marking, marking requirements, radioactive material, hazardous substances in non-bulk packaging.

- Package Labeling 49 CFR 172.400, 49 CFR 172.401, 49 CFR 172.403, 49 CFR 172.406, 49 CFR 172.407, 49 CFR 172.436, 49 CFR 172.438, 49 CFR 172.440: General labeling requirements, prohibited labeling, radioactive materials, placement of labels, specifications for radioactive labels.

- Placarding of Vehicles 49 CFR 172.500, 49 CFR 172.502, 49 CFR 172.504, 49 CFR 172.506, 49 CFR 172.516, 49 CFR 172.519, 49 CFR 172.556: Applicability, prohibited and permissive placarding, general placarding requirements, providing and affixing placards: highway, visibility and display of placards, specifications for RADIOACTIVE placards.

- Emergency Response Information, Subpart G, 49 CFR 172.600, 49 CFR 172.602, 49 CFR 172.604: Applicability and general requirements, emergency response information, emergency response telephone number.

- Training, Subpart H, 49 CFR 172.702, 49 CFR 172.704: Applicability and responsibility for training and testing, training requirements.

- Shippers - General Requirements for Shipments and Packaging, Subpart I, 49 CFR 173.403, 49 CFR 173.410, 49 CFR 173.412, 49 CFR 173.415, 49 CFR 173.431, 49 CFR 173.433, 49 CFR 173.435, 49 CFR 173.441, 49 CFR 173.443, 49 CFR 173.448, 49 CFR 173.475, 49 CFR 173.476: Definitions, general design requirements, additional design requirements for Type A packages, authorized Type A packages, activity limits for Type A packages, requirements for determining A1 and A2 , table of A1 and A2 values for radionuclides, radiation level limitations, contamination

control, general transportation requirements, quality control requirements prior to each shipment, and approval of special form radioactive materials.

- Radiation Protection Program for Shippers and Carriers, Subpart I, 49 CFR 172.801, 49 CFR 172.803, 49 CFR 172.805: Applicability of the radiation protection program, radiation protection program, record keeping, and notifications.

- Carriage by Public Highway - General Information and Regulations, Subpart A, 49 CFR 177.816, 49 CFR 177.817, 49 CFR 177.834(a), 49 CFR 177.842: Driver training, shipping paper, general requirements (secured against movement), Class 7 (radioactive) material.

## 11.0 WASTE MANAGEMENT PROCEDURES

Radioactive wastes including aqueous liquids, dry active wastes, mixed wastes, biological materials and liquid scintillation media will be collected from research areas by the Radiation Safety staff. The waste inventory logs will be used to transfer the radionuclide and activity information from the Authorized User's inventory to the waste inventory. All collected long-lived radioactive wastes will be marshaled in the UNH radioactive waste storage module. The module is part of the UNH Central Hazardous Waste Accumulation Area (CHWAA). UNH maintains a *Central Hazardous Waste Accumulation Area Contingency Plans and Emergency Procedures* document for the site. The CHWAA facility consists of a 2,100 square foot rectangular area. The radioactive storage module is equipped with locks on all doors and is further secured within a locked 8-foot high chain-link fence. This unit will be secured at all times when not in use. Container specific waste inventories will be used to provide the information necessary to ship wastes for off-site disposal. Short-lived collected waste for decay in storage is stored in Parsons Hall in a locked room with access restricted to the RSO and/or his designee. Both storage areas are posted with radioactive material signs. The RSO will determine individual user limits based on the volume of building effluent and the calculations provided in the State of New Hampshire regulations.

UNH generates several different types of radioactive waste: dry active waste, liquid scintillation waste, mixed wastes and aqueous liquid waste. These different waste streams are managed in accordance with the following guidelines.

### 11.1 GENERAL GUIDELINES

- All radioactivity labels must be defaced or removed from containers and packages prior to disposal in ordinary (non-radioactive) waste.

- In all cases, consider the entire impact of various available disposal routes. Consider occupational and public exposure to radiation, other hazards associated with the material, routes of disposal (e.g., toxicity, carcinogenicity, pathogenicity, flammability), and costs.

- The waste management program should include waste handling procedures for the users within their laboratories or assigned areas, and for waste handlers who may collect waste from areas of use to bring to the storage area for eventual disposal.

- Housekeeping staff should be provided adequate training to avoid the possibility of unauthorized disposal or exposure of these individuals to radioactive materials or to radiation.

## 11.2 PROCEDURE FOR DISPOSAL BY DECAY-IN-STORAGE (DIS)

- Only short-lived waste (physical half-life of less than or equal to 90 days) may be disposed of by DIS.

- Short-lived waste should be segregated from long-lived waste (half-life greater than 90 days) at the source.

- Waste should be stored in suitable well-marked containers, and the containers should provide adequate shielding.

- Liquid and solid wastes must be stored separately.

- When the container is full, it should be sealed. The sealed container should be identified with a label affixed or attached to it.

- The identification label should include the date when the container was sealed, the longest-lived radioisotope in the container, date when ten half-lives of the longest-lived radioisotope will have transpired, and the initials of the individual who sealed the container. The container may be transferred to the DIS area.

- The contents of the container should be allowed to decay for at least 10 half-lives of the longest-lived radioisotope in the container.

- Prior to disposal as ordinary trash, each container should be monitored as follows:

  - Check the radiation detection survey meter for proper operation.
  - Survey the contents of each container in a low background area.
  - Remove any shielding from around the container.
  - Monitor all surfaces of the container.
  - Discard the contents as ordinary trash only if the surveys of the contents indicate no residual radioactivity, i.e., surface readings are indistinguishable from background.
  - If the surveys indicate residual radioactivity, return the container to DIS area and contact the RSO for further instructions.

- If the surveys indicate no residual radioactivity, record the date when the container was sealed, the disposal date, type of waste (used or unused material, gloves, etc.), survey instrument used, and the initials of the individual performing surveys and disposing of the waste.

## 11.3 PROCEDURE FOR DISPOSAL OF LIQUIDS INTO SANITARY SEWERAGE

- Confirm that the sewerage system is a public system, not a private sewerage system, septic system, or leach field.
- Confirm that the liquid waste being discharged is soluble or biological material that is readily dispersible in water.
- Calculate the amount of each radioisotope that can be discharged by using the information from prior, similar discharges and the requirements of He-P 4023.03.
- Make sure that the amount of each radioisotope does not exceed the monthly and annual discharge limits specified in He-P 4023.03.
- Record the date, radioisotope(s), estimated activity of each radioisotope, location where the material is discharged, and the initials of the individual discharging the waste.
- Liquid waste should be discharged only via designated sinks, toilets or release points.
- Discharge liquid waste slowly with water running from the faucet to dilute it.
- Survey the sink and surrounding work surfaces to confirm that no residual material or contamination remained in the sink or on work surfaces.
- Prior to leaving the area, decontaminate all areas or surfaces, if found to be contaminated.
- Maintain records of each radioisotope and its quantity and concentration that is released into the sanitary sewer system.

# 12.0 WASTE MINIMIZATION

The goal of the radioactive waste minimization program is to reduce or eliminate radioactive waste as much as feasibly possible to minimize concerns to public health and the environment as well as providing a significant cost savings for the University. Waste minimization addresses process changes that can be made to accomplish this goal including oversight and review, investigating possible alternative methods of use and disposal, waste minimization training, and source and volume reduction.

## 12.1 RESPONSIBILITIES

### 12.1.1 RADIATION SAFETY COMMITTEE

- Reviews and monitors waste minimization efforts.
- Supports the goals of the waste minimization program.
- Ensures that the safe use of RAM and regulatory compliance are not compromised.

### 12.1.2 RADIATION SAFETY OFFICER

- Manages the waste minimization program.
- Tracks, documents and reports to management the effectiveness of the program.
- Provides waste minimization training as part of Radiation Worker training.
- Incorporates waste minimization expectations in the Authorized User permit review process.
- Monitors a mockup evolution for any new waste generating procedure.
- Seeks alternative methods of radioactive waste disposal that do not require shipping to a commercial nuclear waste broker.
- Conducts detailed waste minimization surveys of radioactive material posted areas and works with the Authorized User to identify waste minimization challenges and solutions. Assists with identifying resources with which the Authorized User can continue to reduce their waste.
- Periodically inspects the radioactive waste that has been collected to determine whether the waste has been properly segregated from non-radioactive material, as well as long-lived from short-lived radioactive isotopes.
- Tracks the amount of radioactive waste generated by each Authorized User.
- If possible, transfer for reuse radioactive sources to another AU or licensed activity.

### 12.1.3 AUTHORIZED USER

- Implements waste minimization techniques in their respective work areas.
- Reminds Radiation Workers that non-radioactive waste, such as surplus reagents, boxes, and packaging material should not be mixed with radioactive waste.
- Reviews their laboratory's waste generation and monitors all procedures to ensure that radioactive waste is not created unnecessarily.
- Whenever possible, use radioactive material with ½ lives <90 day, such as Sulfur 35 instead of Carbon 14.
- Substitutes the use of non-radioactive materials for radioactive material whenever appropriate.
- Uses only non-hazardous liquid scintillation media unless specifically approved by the Radiation Safety Committee and the RSO.
- Communicates waste minimization techniques that he/she develops with the RSO and other Authorized Users.

## 12.2 TECHNIQUES

- Lab personnel are trained in waste minimization practices annually.
- Order only the amount of radioactive material necessary for the experimental protocol.
- Minimize waste by disposing of only material that is contaminated. If only a portion of a lay down is contaminated, only dispose of that portion as radioactive waste.
- Whenever possible, clean and reuse items instead of disposing to radioactive waste containers.
- Empty shipping containers (excluding stock vials) and packaging material surveyed and disposed via normal trash.
- Segregate known contaminated items from uncontaminated items.
- Where appropriate, use non-porous lipped trays that can be decontaminated if necessary, rather than paper protective coverings.

## 13.0 SPECIAL CONSIDERATIONS FOR LABORATORY ANIMAL USE

This section provides additional information on the use of by-product materials in laboratory animals, in animals used for research in the environment, and by veterinarians. All protocols involving the use of radioactive materials and animals must receive approval from the University of New Hampshire Institutional Animal Care and Use Committee (UNH IACUC).

### 13.1 LABORATORY TRAINING FOR ANIMAL USE

Before allowing an individual to care for animals used in studies with or treated with licensed material, the Radiation Safety Officer (RSO), Authorized User (AU), and/or veterinarian must ensure that he or she has sufficient training and experience to minimize doses, control contamination, handle waste appropriately, etc. Classroom training may be in the form of lecture, videotape, self-study or online using Blackboard and should cover the following subject areas:

- Principles and practices of radiation protection.
- Radioactivity measurements, monitoring techniques, and using instruments.
- Mathematics and calculations basic to using and measuring radioactivity.
- Biological effects of radiation.

Appropriate on-the-job training should consist of:

- Observing authorized personnel using survey equipment, using proper contamination control techniques, and proper disposal of radioactive material.
- Using survey equipment, proper contamination control techniques, and proper disposal of radioactive material procedures under the supervision of, and in the physical presence of, an individual authorized to handle animals treated with licensed material or otherwise containing licensed material.

### 13.2 CONTAMINATION CONTROL AND WASTE HANDLING

In order to minimize the spread of contamination, animals used in studies with or treated with licensed material should be housed in cages or stalls separate from other animals. The facilities, stalls, or cages shall be secured to prevent unauthorized access to the animals. Individuals caring for these animals should reduce the chance of personal contamination by wearing gloves, a lab coat, and eye protection, as appropriate. Special care should be observed when cleaning the cage or stall. The cage or stall, the bedding, and waste from the animal may

contain radioactive material. Any radioactive material should be properly disposed of as described in Section 11, Waste Management.

Disposal of laboratory animals that contain radioactive material requires special procedures. Animal carcasses that contain less than 1.85 kBq/gram (0.05 microcuries/gram) of carbon-14 or hydrogen-3 may be disposed of by the same method as non-radioactive animal carcasses. Animal carcasses that contain by-product material with a half-life of less than 90 days may be allowed to decay-in-storage in a freezer dedicated for radioactive material. Animal carcasses must be held for a minimum of 10 half-lives of the longest lived isotope. After 10 half-lives, the animal carcasses may be disposed as non-radioactive, if radiation surveys (performed in a low background area and without any interposed shielding) of the carcasses at the end of the holding period indicate that radiation levels are indistinguishable from background (See Section 11.0, Waste Management).

Refresher training is required annually for all Radiation Workers as stated in RPP Section 2.1. Additional on the job training may occur as deemed necessary by the RSO, Authorized User and if required by the RSC. The UNH Animal Resources Office maintains rigorous biosecurity measures for all facilities that house animals as required by the UNH Manual for the Care and Use of Animals. All areas in which animal research involving radioactive materials is conducted will be secured from unauthorized access. Access is restricted to Authorized Users and the RSO. Ancillary employees are restricted from access to these areas. The RSO is responsible for all radioactive waste disposal operations. All wastes generated as a result of this research will be secured from unauthorized access and stored in a temperature-controlled environment until packaged for disposal.

Contaminated animal carcasses and bedding will be managed according to the appropriate strategy (e.g. decay-in-storage, release as non-radioactive or packaging and off-site processing and disposal, etc.). The freezer for storage of animals is located in a secure storage area within the Animal Resources Facility in Rudman Hall. The freezer is locked and access is restricted to the Authorized User and the RSO. Presently UNH anticipates small to medium sized animals will be employed in research activities. UNH does not allow animals to be released to the environment that have been injected with a radiopharmaceutical or implanted with radioactive seeds.