# Radiation Safety Manual

University of Nebraska Omaha

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# Radiation Safety Manual

This manual serves as a reference guide for users of radioisotope at the University of Nebraska at Omaha. The manual has been adapted from the University of Nebraska Medical Center Radiation Safety Manual. We wish to thank Frank Rutar, and the rest of the Staff at the University of Nebraska Medical Center Chemical and Radiation Safety Office for their continued support and guidance.

**Radiation Safety Manual**
**University of Nebraska at Omaha**

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## SECTION A
## ADMINISTRATIVE POLICIES

### *A-1. Radiation Safety Organization*

Ionizing radiation is a versatile tool in biological research. Since ionizing radiation is potentially hazardous, strict safety rules have been developed and implemented. The University of Nebraska at Omaha (UNO) radiation safety program endeavors to keep occupational radiation exposure as low as reasonably achievable (ALARA) to protect UNO employees, students, and the public from unnecessary and potentially harmful radiation exposure.

Five levels of responsibility are involved in the radiation safety program.

A. CHANCELLOR: This individual delegates sufficient authority to the Radiation Safety Officer to establish and enforce radiation safety policies and procedures.

B. RADIATION SAFETY OFFICER (RSO): This is an individual designated by the radioactive materials license who is responsible for radiation safety compliance with campus, state and federal regulations.

C. AUTHORIZED USER: Faculty members authorized by the state license to use radioactive materials and to supervise the use of radioactive materials by radiation workers.

D. RADIATION WORKER: Scientists, students and technical employees engaged in research activities that involve radioactive materials. These personnel work under the supervision of Authorized Users.

E. TRAINEE: Individuals who are developing the skills and knowledge to become Radiation Workers. These personnel work under the supervision of Authorized Users or Radiation Workers.

F. ANCILLARY PERSONNEL: Individuals who may have access to labs containing radioactive material, but do not work directly with radioactive material. This includes: Custodians, Maintenance and Utilities Services, Shipping and Receiving, and students who may use or frequent applicable laboratories, but do not work directly with radioactive materials.

### *A-2. Responsibilities*

A. CHANCELLOR: The UNO chancellor will ensure that all employees, students and visitors, utilize ALARA concepts for radioactive materials. This responsibility is carried out by:

1) Delegation of sufficient authority to the radiation safety officer to enforce regulations and UNO policies and procedures regarding radiation safety.

2) Evaluation of the radiation safety program through appropriate reviews of personnel requirements, budget requirements and operational efforts to maintain radiation doses ALARA.

3) Appropriate consultation with the radiation safety officer to ensure that new facilities, renovations, modifications or equipment, which may influence the conduct of the radiation safety program, will be properly designed and implemented.

B. RADIATION SAFETY OFFICER (RSO): The RSO is responsible for:

1) Coordinating the safe use of radioactive materials.

2) Ensuring that UNO complies with Nebraska Department of Health and Human Services (NHHS) regulations 180 NAC 1 and the established ALARA program

3) Receiving, monitoring and logging radioactive material shipped to UNO.

4) Ensuring that UNO complies with the following conditions of the radioactive materials license:
   a) Radioactive materials possessed conforms to the materials listed on the license.
   b) Radioactive materials are used only by authorized users.
   c) Radioactive materials are secured against unauthorized removal.

5) Coordinating the radiation safety training program for personnel in the laboratories of authorized users.

6) Ensuring proper record keeping.

7) Serving as a point of contact and giving assistance in case of emergency.

8) Notifying proper authorities in case of accident.

9) Coordinating proper disposal of radioactive waste.

10) Instructing personnel in the proper procedures for the use of radioactive materials

11) Distribution and processing of personnel monitoring equipment including the keeping of records of personnel exposure.

12) Performing monthly swipe test of all laboratories.

C. AUTHORIZED USER: Authorized Users (AU) are responsible for ensuring that individual responsibilities are discharged by those under their control, and are further responsible for:

1) Adequate Planning. Before an experiment is performed, the AU should determine the types and amount of radiation or radioactive material to be used. This will generally give a good indication of the protection required. The procedure must be well outlined. In many cases, before the procedure is actually performed with radioactive materials, it should be rehearsed to preclude problem areas or unexpected circumstances. In any situation where there is an appreciable radiation hazard, the Radiation Safety Officer shall be consulted before proceeding.

2) Instructing supervised employees in safe techniques, the application of approved radiation safety practices and the established ALARA program. Ensuring attendance at required radiation safety courses.

3) Furnishing the Radiation Safety Officer with information concerning individuals and activities in their areas--particularly, changes in their personnel rosters and requested changes to authorized room locations.

4) Contacting the Radiation Safety Officer whenever major changes in operational procedures, alterations in use locations (e.g., the removal of radiochemical fume hood), or when new operations which might lead to personnel exposure are anticipated.

5) Complying with the regulations governing the use of radioactive materials. This includes:

   a) Utilizing the correct procedure for the procurement of radioactive materials by purchase or transfer.

   b) Posting areas where radionuclides are kept or used, or where radiation areas may exist.

   c) Performing and recording follow-up swipe test of contaminated equipment or areas so designated by the RSO.

   d) Recording the receipt, transfer, and disposal of radioactive materials.

   e) Ensuring that radioactive waste requirements are followed.

   f) Taking steps to prevent the transfer of radioactive materials to unauthorized individuals. This includes the proper disposition of radioactive materials possessed by terminating workers.

   g) Ensuring that the ALARA program is implemented in all uses of radioactive material

6) Keeping stocks of stored radioactive materials to a minimum within laboratory areas. Maintaining radionuclide inventory under proper security to prevent unauthorized use.

7) Complying with the proper procedure for termination of employment or termination of any experiment using radioactive materials. The Authorized User is reminded that, under the terms and conditions of the license, he must return to the Radiation Safety Officer all radioactive materials (including waste) assigned to him under the license. Particular care should also be exercised to see that specialized equipment such as personnel monitoring devices (e.g., film badges), and shielding materials are returned to the Radiation Safety Officer. A final termination survey must also be performed.

D. RADIATION WORKER and TRAINEE: Each individual who has any contact with radioactive materials is responsible for:

1) Keeping his exposure to radiation as low as reasonably achievable (ALARA), and specifically below the maximum permissible exposure as listed in the following table

REM PER CALENDAR YEAR

| | |
|---|---|
| Effective Dose Equivalent | 5 |
| Eye Dose Equivalent | 15 |
| Shallow Dose Equivalent to the skin or to any extremity | 50 |

In keeping with the ALARA program, UNO has set a goal of maximum permissible exposure of 10% of the above rates

REM PER CALENDAR YEAR

| | |
|---|---|
| Effective Dose Equivalent | 0.5 |
| Eye Dose Equivalent | 1.5 |
| Shallow Dose Equivalent to the skin or to any extremity | 5.0 |

2) Applying the principles of time, distance and shielding to lower exposures.

3) Wearing the prescribed monitoring equipment such as film badges or pocket dosimeters in radiation areas. Personnel who work only with pure alpha emitters or only with pure beta emitters having a maximum energy of less than 0.25 MeV will not be required to wear film badges. This includes H-3, C-14, S-35 and P-33.

4) Surveying hands, shoes, and body for contamination, removing all loose contamination before leaving the laboratory.

5) Utilizing appropriate protective measures such as:
   a) Wearing protective clothing whenever contamination is possible. Do not wear such clothing outside of the laboratory area if contaminated.
   b) Wearing gloves or double gloves if necessary.
   c) Using shields or other protective barriers whenever practical.
   d) Using pipette-filling devices. Never pipette radioactive material by mouth.

6) Not smoking or eating in radionuclide laboratories. Eating may be permitted in an office area of a laboratory that has been demonstrated to be free of contamination. Refrigerators shall not be used jointly for foods and radioactive materials.

7) Maintaining good safety practices.
   a) Gloves should be worn at all times when working with radioactive materials.
   b) Do not work with radioactive materials if there is a break in the skin below the wrist without first covering it.
   c) Wash hands thoroughly after handling radioactive materials.

8) Surveying the immediate areas, e.g. hoods, benches, etc., in which radioactive materials are being used. Any contamination observed should be clearly marked and decontaminated.

9) Keeping the laboratory neat and clean. The work area should be free from equipment and materials not required for the immediate procedure. Whenever practical, keep work surfaces covered with an absorbent material to limit and collect spillage in case of an accident.

10) Labeling and isolating radioactive waste and equipment, such as glassware, used in laboratories for radioactive materials. Once used for radioactive substances, equipment should not be released from the laboratory until demonstrated free from contamination.

11) Requesting supervision from the Authorized user during any repair of contaminated equipment. At no time shall servicing personnel be permitted to work in radiation areas without a member of the laboratory present to provide specific information.

12) Reporting accidental inhalation, ingestion, or injury involving radioactive materials to the supervisor or to the radiation safety officer. The individual shall cooperate in all attempts to evaluate his/her exposure.

13) Carrying out decontamination procedures when necessary, and for taking the necessary steps to prevent the spread of contamination to other areas.

14) Ensuring training requirements are followed.

15) Complying with the "Safety Rules," "Emergency Procedures," and 'Notice to Employees" posted in the laboratory.

E. ANCILLARY PERSONNEL: Each individual who enters a laboratory that uses radioactive materials is responsible for:

1) Complying with warning signs and directions given by the Radiation Safety Officer, Authorized User, and/or Radiation Workers in the applicable laboratory.

2) Notifying Authorized User and Radiation Safety Officer of any action that may disturb areas where radioactive materials are used or stored.

3) Reporting any accident or incident involving radioactive material to the authorized user and Radiation Safety Officer.

F. PROCEDURES FOR OBTAINING PERMISSION TO USE RADIOACTIVE MATERIALS:

Each worker must obtain permission from an authorized user to use radioactive material in any experiment. The user must first review the experiment and any safety requirements with the worker before giving permission to use radioactive material. Only users or their authorized agents are allowed to order radioactive material. All radioactive material order requests must be forwarded to the Radiation Safety Office at least 24 hours prior to placing the orders.

G. LIMITATIONS ON QUANTITIES OF RADIOACTIVE MATERIAL TO BE HANDLED BY USERS, WORKERS AND TRAINEES.

| | $^{32}P$ | $^{35}S$ | $^{125}I$ | $^{3}H$ | $^{33}P$ | $^{14}C$ |
|---|---|---|---|---|---|---|
| User | 2 mCi | 2 mCi | 50 µCi | 5 mCi | 2 mCi | 2 mCi |
| Worker | 2 mCi | 2 mCi | 25 µCi | 5 mCi | 2 mCi | 2 mCi |
| Trainee | 100 µCi | 100 µCi | 5 µCi | 100 µCi | 100 µCi | 100 µCi |

## *A-3 Radioactive Materials License*

A. INTRODUCTION

UNO operates its Radiation Safety Program under the authority of a specific license for laboratory and industrial use of small quantities of radioactive material issued by the NHHS Radioactive Materials Program. The license was issued to reflect the information submitted in the license application and contains specific conditions and limitations, which must be followed. The terms and conditions of the license can be obtained by contacting the Radiation Safety Officer. It is important to remember that the State license is a legal document in which Civil Penalties may be imposed for violations of license conditions. NHHS must formally approve amendments to the radioactive materials license (i.e. to add an authorized user or to change the possession limit for an isotope) before changes in current practices are made.

B. AMENDMENTS

Revisions to the existing license must be submitted to NHHS, in written form. Amendments must be approved prior to initiating any changes. Amendments must be made for any of the following:

1) Change in the type of radionuclide being used.

2) Any increase in the maximum amount of activity to be possessed at any one time.

3) Any procedure that is in conflict with existing license conditions.

4) Changes in authorized use locations.

5) Use of a different chemical and/or physical form that increases the radiological risk to personnel (e.g., changing from an I-125 labeled compound to NaI).

6) Change in authorized use (e.g., adding animal studies).

C. REVOCATIONS

Permission to use radioactive materials as an authorized user can be revoked at any time by the RSO. The criteria for revocation includes but is not limited to:

1) Unsafe use of radioactive material posing a health and safety problem (as determined by the RSO).

2) A serious violation of the Radiation Safety Manual or State Regulations (i.e. failure to provide personnel monitoring when required).

3) Repeated violations of the Radiation Safety Manual or State regulations (i.e. failure to conduct contamination surveys at regular intervals when radioactive material is present in the laboratory).

D. AUDITS AND INSPECTIONS

Authorized users are subject to audits and inspections at any time.

1) NHHS, Radioactive Materials Program, makes routine inspections of licensees. During these inspections, the State will select a suitable number of Authorized Users to review. This may include an administrative review of all applicable documentation and a walk-through inspection of the authorized use locations. Any items of non-compliance will be addressed to the UNO Chancellor.

2) The Radiation Safety Officer shall review the radiation protection program content and implementation at intervals not to exceed 12 months.

3) The Radiation Safety Officer audits Authorized Users for the purpose of identifying problem areas, which can be corrected intramurally.

a) Standard Audit
These audits are intended to model State inspections so that the Authorized Users are better prepared for a State Audit. Items of non-compliance previously identified are reviewed so that they are not repeated.

b) Performance-Based Audit
Performance-based audits review radiation safety techniques employed during actual use of radioactive material. The performance-based audits should include some or all of the following:

1) Lab coats and protective gloves worn.
2) Personnel monitor for contamination when exiting a controlled area.
3) Personnel monitor items (e.g., gloves) prior to disposal as normal trash.
4) No eating, drinking, or chewing gum in use or storage areas.
5) No food, drink, or personal effects kept in use or storage areas.
6) Whole body badges worn properly.
7) Independent radiation measurements.

E. PERFORMANCE-BASED TRAINING

An assessment of the comprehension and abilities of Authorized Users or Radiation Workers is included in the Radiation Safety Program. Performance-based training refers to the “hands-on” aspect of working habits, used in day-to-day operations. Performance-based aspects are normally reviewed during laboratory audits. A summary of these practices is listed below:

1) Are individuals wearing their dosimetry in the proper manner? Whole body OSL badges are to be worn on the collar. Ring badges (if used) are to be worn on the dominant hand with dosimeter chip turned inward toward palm.

2) Are all individuals wearing protective clothing while working with radioactive material? Lab coats and gloves are to be worn when working with radioactive material.

3) Are individuals monitoring their gloves for radioactivity in order to determine if they should be put in the radioactive waste or normal waste? Gloves that read above background must be put in the radioactive waste. Gloves, which are indistinguishable from background, may be put in the normal waste. An appropriate meter that detects the type of radiation used must be selected. Gloves must be monitored in a low-background area.

4) Are individuals monitoring their hands and lab coat before leaving the lab area? To prevent the spread of contamination, individuals should perform a thorough survey prior to leaving the area.

5) No food, chewing gum, or drinks are allowed in a restricted area.

6) Is radioactive material secured at all times when not attended? All radioactive material should be locked in freezers, refrigerators, or storage areas to prevent unauthorized removal.

7) Is appropriate shielding being used to maintain the dose ALARA at all times? All sources should be stored in a suitably shielded pig. Waste must also be shielded in a secured area.

8) Are all areas covered with an absorbent pad or paper where unsealed radioactive material is used? Absorbent pads will contain any spills and facilitate cleanup.

9) Are survey instruments checked each time prior to use? The instrument must be returned to the battery check position to verify that there is ample power to the instrument. The instrument must be presented to a check source to verify the probe is functioning properly. The check source reading must be within ±20% of the calibration sticker.

10) Are all individuals familiar with the appropriate frequencies and actions level for area surveys in their laboratories? Work areas should be surveyed with a meter after each use. Readings that are twice above background should be wiped.

11) Are all individuals familiar with the wipe test requirements? The removable contamination from a wipe test should not exceed 220 dpm/100cm$^2$ for beta & gamma emitters, and 22 dpm/100cm$^2$ for alpha emitters. The frequencies are based on the amount of radioactive material processed during a month.

12) Are all wipe test results being recorded in dpm or are conversion factors correlating cpm to dpm documented? Recording results as “background” or “cpm” alone is not acceptable.

## *A-4 Training and Experience Requirements*

Authorized Users and Workers are able to utilize radioactive material and supervise the use of radioactive material. Supervise means to be available to trainees at all times by being directly available to trainees physically in the laboratory or in the building in which the lab is located or available by telephone or pager to the trainees within 10-15 minutes from the time of the call or page. The Authorized Users and Workers are specifically listed on the radioactive materials license and have been approved by NHHS. Authorized Users, and Workers must meet the requirements of the State Regulations (180 NAC 15-017) for training and experience as follows:

A. **Radiation Safety Officer**

1) A college degree at the bachelor level, or equivalent training or experience, in the physical or biological sciences or in engineering; and
2) Forty hours of formal instruction in:
    a) Radiation physics and instrumentation;
    b) Radiation protection;
    c) Mathematics pertaining to the use and measurement of radioactivity, and
    d) Biological effects of radiation; and
3) Demonstrate an understanding of institution radiation safety policy and procedures and Title 180 or their equivalent.

B. **Authorized User**

1) A college degree at the bachelor level, or equivalent training or experience, in the physical or biological sciences or in engineering; and
2) Forty hours of formal instruction in:
    a) Radiation physics and instrumentation;
    b) Radiation protection;
    c) Mathematics pertaining to the use and measurement of radioactivity, and
    d) Biological effects of radiation; and
3) Demonstrate an understanding of institution radiation safety policy and procedures and Title 180 or their equivalent.

C. **Radiation Worker**

1) A college degree at the bachelor level, or equivalent training or experience, in the physical or biological sciences or in engineering; and
2) Forty hours of formal instruction in:
    a) Radiation physics and instrumentation;
    b) Radiation protection;
    c) Mathematics pertaining to the use and measurement of radioactivity, and
    d) Biological effects of radiation; and
3) Demonstrate an understanding of institution radiation safety policy and procedures and Title 180 or their equivalent.

D. **Radiation Trainee**

Radiation Trainees are laboratory research personnel or students who will be working in a laboratory authorized to use radioactive material. These individuals must work under the supervision of an Authorized User or Radiation Worker. Before using radioactive

material, a Radiation Trainee must:

1) View available Radiation Safety videos and take an associated comprehension test. The videos and tests are available from the Radiation Safety Officer. A form is available from the Radiation Safety Officer to document this training. The videos will cover (at a minimum):

   a) Introduction to Radiation Protection
   b) Laboratory Techniques
   c) Emergency Preparedness and Response

2) Review the contents of the Radiation Safety Manual.
3) Review the contents of the Radiation Safety Posters found in the lab.
4) Review laboratory safety requirements with the Authorized User.

E. **Ancillary Personnel**

Individuals who may have access to labs containing radioactive material, but do not work directly with radioactive material.

Ancillary personnel must receive basic radiation safety orientation, including the meaning of warning signs and proper emergency procedures prior to work in and around radioactive materials.

The Radiation Safety Officer or appropriate Authorized User must notify individuals, whose work frequently takes them into areas where radioactive material is used, as to the risks present in those areas and precautions necessary to safely carry out their duties.

## *A-5 Overview of the ALARA Program*

UNO is committed to maintaining radiation exposure to workers and the public from radiation sources to "As Low As is Reasonably Achievable" (ALARA). The policy used by UNO is based on NHHS Radioactive Materials Program regulations and incorporates United States Nuclear Regulatory Commission Regulatory Guides. The ALARA program at UNO emphasizes the following objectives:

1) Maintain individual and collective Total Effective Dose Equivalent ALARA.

2) Identify responsibilities at all levels of organization.

3) Training of workers regarding policies, goals and methods to achieve dose reduction with emphasis on personal responsibility in the performance of their duties.

4) Incorporate design features into plans when evaluating existing or new protocols to maintain ALARA.

A. RESPONSIBILITIES

Overall program responsibility for efforts to maintain exposures ALARA resides with the Chancellor and the RSO. In addition to those responsibilities listed in Section A-2, the RSO reviews the effectiveness of the ALARA program and reviews tasks and procedures with potentially significant exposures.

The RSO, in addition with those duties mentioned in Section A-2, has the responsibility for administering the day-to-day operations of the ALARA program and ensures recommendations are implemented. If needed, this individual provides radiological engineering assistance and special training in proper radiation protection practices and procedures.

The Authorized User, in addition to those responsibilities listed in Section A-2, has responsibility to ensure the radiation workers under their supervision utilize ALARA principles. They will provide training to individuals under their supervision in protocol techniques that will reduce radiation exposure, and to work with the RSO in implementing recommendations.

Radiation Workers have the responsibility to follow the guidelines set in the Implementation portion of this section, in order to maintain their exposures ALARA.

B. IMPLEMENTATION

Overall ALARA program direction is the responsibility of the UNO Chancellor, under advisement by the Radiation Safety Officer. Responsibilities for implementation of the ALARA program are summarized here:

1) Use temporary shielding when needed.
2) Review protocols to ensure elimination of unsafe practices.
3) Recognize good radiation protection practices
4) Provide annual radiation protection training/workshops for all individual users.
5) Provide audits of Authorized Users, to include evaluation of:
    a) Proper storage and shielding of radioactive material.
    b) Inventory control.
    c) Record keeping (i.e., amount of activity on hand, contamination surveys, sewer disposal).
    d) Radiation surveys.
    e) Instrument operation.
    f) Verification of training completed.
    g) ALARA techniques being implemented during protocols, etc.

6) Notifications to affected personnel when systems are to be taken out of service for maintenance purposes.

7) Monitoring exposures through dose tracking for applicable individuals.

Data and information acquired from the above activities are evaluated by the RSO to assess the effectiveness of the UNO ALARA program.

## SECTION B
## PROCEDURES

### *B-1 Control of Radioactive Material.*

A. ORDERING RADIOACTIVE MATERIAL.

Prior to ordering, AUs must obtain permission from the RSO to do so. The RSO is responsible for ensuring that radioactive materials orders will stay within the activity authorized by UNO's radioactive materials license. Radioactive Material is not accepted during off-duty hours. The RSO will maintain records to ensure adherence to possession limits. All Radioactive Material will be stored in locked refrigerators to ensure against unauthorized removal.

B. RECEIVING AND OPENING RADIOACTIVE MATERIAL PACKAGES.

All radioactive materials packages must be received by the RSO. Before a package is released to the laboratory, it is inspected as follows:

1) The external surfaces of a labeled package will be monitored for radioactive contamination unless the package contains only radioactive material in the form of a gas or in special form as defined in 180 NAC 1-002; or

2) The external surfaces of a labeled package will be monitored for radioactive contamination unless the package contains quantities of radioactive material that are less than or equal to the type A quantity as defined in 180 NAC 13-002 and Appendix 13A; or

3) All packages known to contain radioactive material will be monitored for radioactive contamination and radiation levels if there is evidence of degradation of package integrity, such as packages that are crushed, wet, or damaged.

The required monitoring shall be performed as soon as practicable after receipt of the package, but not later than 3 hours after the package is received at the facility if it is received during normal working hours, or not later than 3 hours from the beginning of the next working day if it is received after working hours.

The final delivery carrier and the NHHS Radioactive Materials Program shall be immediately notified if the removable radioactive surface contamination exceeds the limits of 180 NAC 13-015.09, or if external radiation levels exceed the limits of §13-015.10 or 13-015.11.

Once the package has been monitored, it is released to the laboratory. When a radioactive material package is received in the laboratory, there is a chance that radioactive material has leaked out of the inner stock vial. Always assume that the package is contaminated until proven otherwise. Laboratory personnel opening radioactive material packages should use the following procedure:

a) Wear gloves.

b) Check to make sure that the contents listed on the vial match the packing slip.

c) Remove and monitor the vial with a survey meter, wipe test the inner container if contamination is suspected.

d) If contamination is not found, store the radioactive material in a secure storage area that is conspicuously posted for radioactive material.

e) If contamination is found, dispose of all contaminated shipping material as radioactive waste. If the radioactive material is still usable, clean the outside of the vial and store in an area posted for radioactive material. Survey the area for contamination.

f) Deface or remove all radioactive symbols on the shipping box and dispose as normal trash.

g) If radioactive iodine packages are found leaking, immediately notify the Radiation Safety Officer so that a bioassay can be arranged.

C. INVENTORY CONTROL

The license specifies possession limits for each isotope. This is the total amount of radioactive material that UNO can be in possession of at any given time. This includes material held in storage or in waste. Contaminated material shall be packaged in clearly marked containers and stored in the radioactive waste storage room for decay or held for disposal by a certified institution

The form RSO-8 serves to record receipt and disposal of each individual shipment. When the material is received by the RSO, it is recorded in a log under the authorized user's name. The only way that material can be deleted from the log is when the RSO receives the form RSO-8 indicating that the material has been disposed of or decayed. If the total inventory approaches the maximum possession limit, further orders will not be approved. Each authorized user should have on hand only those RSO-8 forms for which material is present in the lab. This will ensure a correct inventory. Inventories will be reviewed during inspections and/or audits of the laboratory. The movement of radioactive material between rooms, halls or corridors shall be done in sealed containers with appropriate labeling on each container as described below.

## *B-2 Caution Signs, Warnings, and Labels*

A. When is a "Caution - Radioactive Material" sign required in a room or area?

When radioactive material is used or stored in an amount exceeding 10 times the quantity specified in §4-C. The values for the most commonly used radionuclides are listed below:

| | | |
|---|---|---|
| Carbon-14 | 1000 | µCi |
| Hydrogen-3 | 10000 | µCi |
| Iodine-125 | 10 | µCi |
| Phosphorous-32 | 100 | µCi |
| Phosphorous-33 | 1000 | µCi |
| Sulfur-35 | 1000 | µCi |

**NOTE: These are 10 times §4-C values.**

Exemptions:

1) A room or area is not required to be posted with a caution sign because of the presence of a sealed source, provided the radiation level thirty (30) centimeters (12 inches) from the surface of the source container or housing does not exceed five (5) mrem per hour (0.05 mSv/h).

2) Caution signs are not required to be posted in areas or rooms containing radioactive material for periods less than eight (8) hours provided that (1) the material is constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the established limits, and (2) such an area is subject to the Authorized User's control.

3) A room or other area is not required to be posted with a caution sign, and control is not required for each entrance or access point to a room or other area which contains radioactive material solely for the purpose of receiving radioactive materials packages, provided the packages are labeled in accordance with regulations of the U.S. Department of Transportation.

B. When is a "Caution-Radioactive Material" sign or tape required on a Container?

When a container has a quantity of radioactive material equal to or greater than those listed in § 4-C. Values for the most commonly used radionuclides are listed below:

| | | |
|---|---|---|
| Carbon-14 | 100 | µCi |
| Hydrogen-3 | 1000 | µCi |
| Iodine-125 | 1 | µCi |
| Phosphorous-32 | 10 | µCi |
| Phosphorous-33 | 100 | µCi |
| Sulfur-35 | 100 | µCi |

Each authorized user shall, prior to disposal of any uncontaminated empty container to an unrestricted area, remove or deface the radioactive material label or otherwise clearly indicate the container no longer contains radioactive materials.

Exemptions:

1) Containers holding licensed or registered material in quantities less than the those specified in §4-C; or

2) Containers holding licensed or registered material in concentrations less than those specified in §4-B; or

3) Containers are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation in excess of the limits; or

4) Containers when they are in transport and packaged and labeled in accordance with the regulations published by the U.S. Department of Transportation; or

5) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record. Examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells. The record shall be retained as long as the containers are in use for the purpose indicated on the record; or

6) Installed manufacturing or process equipment, such as piping and tanks.

C. Are Any Other Postings Required?

Only when there is enough radioactive material in an area to cause a Radiation Area, High Radiation Area, or Very High Radiation Area. The following table specifies the required postings:

| Dose Rate | Distance From Source | Posting Required |
|---|---|---|
| 5 mrem in any one hour | 30 cm | Caution, Radiation Area |
| 100 mrem in any one hour | 30 cm | Caution, High Radiation Area |
| 500 Rad in any one hour | 1 meter | Grave Danger, Very High Radiation Area |

The Radiation Safety Officer will verify all High Radiation Areas and ensure that proper controls are exercised.

D. What About Airborne Radioactivity?

If the activities you are engaged in are suspected to create airborne radioactivity (e.g., vapors, aerosols), the Radiation Safety Officer can conduct the appropriate surveys and calculations to determine if posting the area is required. If necessary, these areas will be posted "Caution–Airborne Radioactivity Area."

E. When and How Are Rooms and/or Areas Posted?

The Radiation Safety Officer will arrange a time to conduct the posting of each authorized use location prior to approving that location for radioactive material use.

F. What About Rooms or Areas That Are No Longer Used for Radioactive Material?

The Authorized User is responsible for notifying the Radiation Safety Officer by memo so that areas may be de-posted.

G. What Are the Consequences of Improper Posting and Labeling?

Regulatory noncompliance with NHHS will result. State inspectors will verify postings during University inspections.

### *B-3 Safe Handling Practices for Radioactive Materials*

A. RADIATION SAFETY RULES TO BE OBSERVED IN THE LABORATORY.

Each authorized user has a yellow poster in the laboratory listing the safety rules to be observed in the lab. These are reproduced below.

1) Do not eat, drink, smoke, or apply cosmetics in the laboratory.

2) Wear gloves and protective clothing (e.g. lab coat) when working with radioactive material in any form other than a sealed source.

3) Never pipette radioactive solutions by mouth.

4) Do not expose open wounds to the possibility of radioactive contamination.

5) Do not store food or drink in the same storage location (e.g. refrigerator) as radioactive material.

6) Clearly label containers holding radioactive materials with the words "Caution: Radioactive Material" and the radiation symbol.

7) Work with radioactive materials over absorbent paper and/or trays to contain contamination.

8) Work with radioactive materials that could become airborne in a ventilated enclosure such as a fume hood.

9) Use appropriate shielding to keep the dose rate as low as reasonably achievable.

10) Wear film badge or other specified personnel monitor (except for $^{3}H$, $^{14}C$, $^{33}P$ and $^{35}S$).

11) Monitor during and after procedure to ensure that exposure rates are kept low and that work area has not become contaminated. Decontaminate any contaminated area.

12) Monitor entire person after performing a radioactive procedure and before leaving the laboratory. Notify Radiation Safety if any contamination is not easily removable.

13) Monitor equipment or other materials before removing from a restricted area. Decontaminate as necessary.

14) Dispose of radioactive waste in accordance with the methods approved by the Radiation Safety Manual.

15) Notify the Radiation Safety Officer at 4-3921 (campus phone) or 402-660-1598 immediately if radioactive material has been or is suspected to have been inhaled or ingested into a person.

16) Never leave radioactive material unattended unless it has been secured against unauthorized removal.

17) Record details of contamination events for the Radiation Safety Officer's review.

B. Notice to Employees

Each authorized user also has a yellow poster in the lab titled "Notice to Employees". This poster specifies:

1) Your employer's responsibility.

2) Your responsibility as a worker.

3) What is covered by these regulations.

4) Reports on your radiation exposure history.

5) Inspections

In addition, a copy of the regulations, the radioactive license, and notices of violations are available for inspection in the RSO Office. Each individual should familiarize themselves with these provisions for their own protection and that of their coworker-workers.

C. SPECIFIC GUIDELINES FOR THE SAFE USE OF COMMONLY USED RADIONUCLIDES.

Specific guidelines have been developed for using common isotopes. The guidelines for the following isotopes appear in the numbered Appendices of this manual:

1) $^{3}H$
2) $^{14}C$
3) $^{32}P$
4) $^{33}P$
5) $^{35}S$
6) $^{125}I$

## *B-4 Emergency Procedures for Incidents Involving Radioactive Materials.*

A. SPILLS.

The following instructions apply only to the radiation aspects of an incident. If injuries occur, the procedures must be coordinated with appropriate first aid measures and priorities assigned to providing necessary medical care. Spills involving radioactive material are classified as either Major or Minor. Initiate a minor or major spill procedure by estimating the amount of radioactivity spilled and applying it to the table below. Spills below these millicurie amounts are considered minor and those above are considered major.

| | | |
|---|---|---|
| Carbon-14 | 10 | mCi |
| Hydrogen-3 | 100 | mCi |
| Iodine-125 | 1 | mCi |
| Phosphorous-32 | 10 | mCi |
| Phosphorous-33 | 10 | mCi |
| Sulfur-35 | 10 | mCi |

B. PROCEDURES FOR MINOR SPILLS

Each authorized user has a yellow poster in the laboratory titled "Emergency Procedures for Incidents Involving Radioactive Material". This poster contains the step-by-step procedure and is reproduced below.

Minor spills involving minimal external radiation hazard to personnel:

1) Notify all persons in the room to leave at once.

2) Permit only the minimum number of persons necessary to deal with the spill into the area.

3) Confine the spill immediately.
   a) Liquid Spills:
      i) Don protective gloves
      ii) Drop absorbent paper on the spill

   b) Dry Spills
      i) Don protective gloves
      ii) Dampen thoroughly, taking care not to spread the contamination

4) Notify the Radiation Safety Officer as soon as possible at 4-3921 (campus phone) or 402-660-1598.

5) Decontaminate

6) Monitor all persons involved in the spill and cleaning.

7) Permit no persons to resume work in the area until a survey is made and approval of the Radiation Safety Officer is secured.

8) Prepare a complete history of the accident and subsequent activity related thereto for the laboratory records.

C. PROCEDURES TO FOLLOW FOR MAJOR SPILLS

Each authorized user has a yellow poster in the laboratory titled "Emergency Procedures for Incidents Involving Radioactive Materials". This poster contains step by step procedures and is reproduced below:

Major Spills Involving External Radiation Hazard to Personnel.

1) Notify all persons not involved in the spill to vacate the room at once.

2) If the spill is liquid and the hands are protected, right the container.

3) If the spill is on the skin, flush thoroughly.

4) If the spill is on clothing, discard outer or protective clothing immediately.

5) Switch off all fans.

6) Vacate the room and prohibit entrance to contaminated area.

7) Notify the Radiation Safety Officer as soon as possible at 4-3921 (campus phone) or 402-660-1598.

8) Decontaminate skin and/or hair as advised by the Radiation Safety Officer. Any person who might have been involved must remain near the area to be monitored by the Radiation Safety Officer.

9) Decontaminate the area only as directed by the Radiation Safety Officer.

10) Permit no person to enter the area until a survey is made and approval of the Radiation Safety Officer is secured.

11) Prepare a complete history of the accident and subsequent activity related thereto for the laboratory records.

D. RESPONSIBILITY FOR CLEANING UP THE SPILL:

1) For minor spills, the individual who caused the spill is responsible for cleanup and decontamination (the Radiation Safety Officer will supervise if requested). The incident should be reported to the Radiation Safety Officer either by memo or on the monthly survey.

2) For major spills, the Radiation Safety Officer should be notified immediately. The Radiation Safety Officer will supervise the cleanup and decontamination. The Radiation Safety Officer will compile the necessary documentation.

E. OTHER INCIDENTS INVOLVING RADIOACTIVE MATERIALS (e.g. FIRES, EXPLOSIONS)

For any other type of incident involving release of radioactivity, the following guidance should be observed:

1) Immediately call Public Safety at 4-2911 (campus phone) or 402-554-2911.

2) Notify all persons to leave the area immediately.

3) Provide lifesaving first aid if applicable

4) Confine the material to the extent possible without jeopardizing your personal safety.

5) Notify the Radiation Safety Officer as soon as possible at 4-3921 (campus phone) or 402-660-1598.

6) Instruct all persons who may have been contaminated or exposed to remain in a safe location until released by the Radiation Safety Officer.

F. CALL LIST FOR RADIATION EMERGENCIES

1) For incidents not involving personal injury:
Public Safety: 4-2911 (campus phone) or 402-554-2911
Radiation Safety Officer: dial 4-3921 (campus phone) or 402-660-1598.
After hours: 402-895-4030 or 402-660-1598.

2) For incidents involving personal injury:
Public Safety: dial 4-2911 (campus phone) or 402-554-2911.

3) Be prepared to state:
- Your name
- Location
- Radionuclide and quantities involved
- Brief description of the incident
- A call back number where you can be reached

G. PERSONNEL DECONTAMINATION

1) For contamination not involving personal injury (e.g. no open wounds, cuts etc.), the theory of decontamination is relatively simple. Most radioactive contamination on intact skin behaves like loose dirt and may be removed by routine washing. The effectiveness of decontamination procedures for beta and gamma emitting radionuclides are easily monitored by a Geiger counter. For low energy beta emitters (e.g. $^{3}H$) swipes can easily locate external contamination. Radionuclides on the intact skin rarely, if ever, cause a high enough gamma radiation dose to be a hazard if decontamination procedures are carried out promptly. The intact skin is a very effective barrier to internal contamination. Internal contamination may be a hazard

depending upon activity and residence time within parts of the body. Since the main hazard of external contamination is the possibility of internal contamination, external decontamination procedures are designed to (1) minimize or prevent internal contamination and (2) decrease the external contamination that is present. All efforts are made to clean the contamination from the skin, but occasionally it may be fixed or embedded in the skin. The skin barrier must be preserved so that procedures such as shaving or harsh scrubbing are not done. If hair needs to be removed, clipping is effective. Warm water, not hot, is used for washing so that hyperemia is not induced which may increase absorption of any contaminants through the skin. Cold water is not used since it would tend to close pores and trap radioactive contamination. Decontamination is done by progressive cleansing, starting with mild agents such as soap and water and working up to somewhat more involved procedures.

2) The decontamination end point is reached when:
   a) No further decrease occurs as determined by monitoring.
   b) The contamination has decreased to background levels.
   c) When further decontamination would be more harmful than helpful.

3) The procedure for decontamination is as follows:

   a) Remove any contaminated clothing and call the Radiation Safety Officer.
   b) Wash affected body areas for 2 to 3 minutes, repeatedly soaping and rinsing. Use a mild soap (e.g. RadiacWash or Count-Off) and lukewarm water.
   c) Notify the Authorized User immediately after the contaminating event.
   d) Avoid prolonged use of any one decontamination procedure as irritation of the skin may impede the success of a more suitable procedure.
   e) If these measures are not immediately and completely effective, notify the Radiation Safety Officer.

4) For contamination involving personal injury (e.g. open wounds, cuts etc.) the procedure is as follows:

   a) Contact Public Safety extension 4-2911 (campus phone) or 402-554-2911 for immediate help.
   b) Provide first aid and medical stabilization to the extent possible.

## H. DECONTAMINATION OF FACILITIES AND/OR EQUIPMENT

1) Once again the theory of decontamination is simple. Normally routine washing, using mild soap and water, will clean up the areas. Consideration can also be given to the chemistry of the contaminant in attempt to find a suitable dissolving or chelation agent. Preparations for decontamination should begin promptly and begin in the area of least contamination progressing to the area of greatest contamination.

2) If contamination is "fixed" to a surface it may be necessary to remove the surface and place it in the radiological waste. For "fixed" short half-life radionuclides (where

external dose rate is not a personnel hazard), the area may be covered, marked as a contaminated area and left to decay.

3) The internal surfaces of some laboratory equipment may be contaminated during normal use. If these surfaces are impractical to clean, the equipment should be labeled to indicate internal contamination.

4) The decontamination endpoint is reached when:

   a) All removable contamination is cleaned to levels as low as reasonably achievable (ALARA).

   b) For "fixed" contamination, where the external exposure is not significant and the half-life is short, the affected area is covered and labeled.

   c) For "fixed" contamination where external exposure may present a personnel hazard or the half-life is long, the surfaces are removed and placed in the radiological waste.

   d) An equipment surface is inaccessible to personnel (equipment internals) and the equipment is properly labeled to indicate contamination.

### *B-5 Personnel Monitoring*

A. EXTERNAL MONITORING

1) Who must be monitored?

   a) State regulations require that any who is likely to receive 10% of any applicable limit must be provided with a monitoring device. The following table summarizes the values at which external monitoring must be provided:

| | |
|---|---|
| Declared Pregnant Woman (DPW) | 50 mrem/gestation period |
| Whole Body (DDE) | 500 mrem/annually |
| Eye Lens (LDE) | 1,500 mrem/annually |
| Extremity (SDE-ME) | 5,000 mrem/annually |
| Skin (SDE-WB) | 5,000 mrem/annually |

   b) UNO will furnish each worker who is required to be monitored with an annual report of their total effective dose equivalent (sum of external deep dose and any internal committed effective dose equivalent).

c) At the request of a worker who is terminating employment, UNO will provide a termination report regarding the radiation dose received by that worker for the current year or fraction thereof. If the most recent results are not available at that time, a written estimate of the dose will be provided with a clear indication that it is an estimate.

d) If a worker requests a written report of their doses, it will be provided within 30 days after it is received from the company providing the dosimetry service.

2) Individuals who are badged but are not required to be badged.

a) Most individuals who work with radioactive materials at UNO never approach these values. The majority of badged UNO employees receive no measurable exposure.

b) The results of personnel monitoring performed but not required by State Regulations are not required to be reported to the individual. This includes annual reports and terminations.

c) UNO may provide annual reports to all individuals monitored but not required, on an informational basis only.

d) UNO will continue to provide results of any monitoring at the request of a worker.

3) Badge Types

a) Badges are processed by a vendor that holds current accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Bureau of Standards.

b) Badges are not required for individuals when:

1) They are working solely with weak beta emitters of energies less than 150 KeV. (At UNO, only $^{3}H$.qualifies under this exemption).

2) They are exempted by the RSO.

4) What are the limits on exposures?

The maximum permissible dose is as follows:

| | |
|---|---|
| Declared pregnant Woman (DPW) | 500 mrem gestation period |
| Whole Body (DDE) | 5,000 mrem annually |
| Eye Lens (LDE) | 15,000 mrem annually |
| Skin (SDE-WB) | 50,000 mrem annually |
| Extremity (SDE-ME) | 50,000 mrem annually |
| Total Organ Dose Equivalent (TODE) | 50,000 mrem annually |

a) Individuals under 18 years old are limited to 10% of these values.

b) Declared pregnant women are limited to 500 mrem for the entire gestation period unless they have already received 500 mrem since conception. In this case, they are allowed 50 mrem for the remainder of the pregnancy.

c) Weighting factors ($W_T$) are used in calculating the effective dose equivalent. A weighting factor for an organ or tissue is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly.

The values for the weighting factors are as follows:

| **Organ or tissue** | **$W_T$** |
|---|---|
| Gonads | 0.25 |
| Breast | 0.15 |
| Red bone marrow | 0.12 |
| Lung | 0.12 |
| Thyroid | 0.03 |
| Bone surfaces | 0.03 |
| Remainder | [1]0.30 |
| Whole body | 1.00 |

[1]0.30 results from 0.03 for each of 5 "remainder" organs (excluding the skin and lens of the eye) that receive the highest doses.

d) Doses are measured at:

1) Whole Body (DDE) - At the tissue depth of 1 cm (1,000 mg/cm$^2$).

2) Eye Lens (LDE) - At the tissue depth of 0.3 cm (300 mg/cm$^2$).

3) Extremity (SDE-ME) - At the tissue depth of 0.007 cm (7 mg/cm$^2$).

4) Skin (SDE-WB) - At the tissue depth of 0.007 cm (7 mg/cm$^2$).

In accordance with the philosophy of keeping exposures ALARA, the Radiation Safety Office has established a level at which Landauer will provide immediate notification of a higher than normal reading. These levels are as follows:

| | |
|---|---|
| Whole Body (DDE) | 125 mrem/calendar quarter |
| Eye Lens (LDE) | 375 mrem/calendar quarter |
| Skin (SDE-WB) | 1,250 mrem/calendar quarter |
| Extremity (SDE-ME) | 1,250 mrem/calendar quarter |

The Radiation Safety Officer may alter these levels based on regulatory or safety concerns. When an individual exceeds any one of these levels, a follow up survey may be conducted to determine if a reduction in dose can be reasonably achieved.

5) How to enroll in the Fetal Monitoring Program

Any pregnant female radiation worker who wishes to voluntarily enroll in the Fetal Monitoring Program needs to contact the Radiation Safety Officer. She will be provided with a Declaration of Pregnancy Form, which the Radiation Safety Officer will use to calculate the dose received from the date of conception until the date of declaration. Exposure limits for the remaining allowable dose will be set at that time.

A copy of the completed Declaration of Pregnancy form, NRC Regulatory Guide 8.13, and a fetal monitoring badge will be sent to the Declared Pregnant Woman (DPW) as soon as practical. The fetal monitoring badge is to be worn at waist level versus the standard whole body badge, which is worn at the collar. If a lead apron is utilized, the fetal badge is worn under the apron and the whole body badge outside the apron.

The Radiation Safety Officer will closely evaluate the exposure levels for fetal monitoring badges throughout the entire gestation period. A fetal ALARA level has been set by UNO at an exposure of 120 mrem/quarter. Should this level be exceeded, the DPW will receive immediate notification.

At the end of the pregnancy, the DPW will contact the Radiation Safety Office to discontinue the fetal monitoring badge. If requested, a Fetal Exposure final report will be generated.

6) How to terminate the badge program.

It is each individual's responsibility to notify the Radiation Safety Officer when they terminate work involving radiation exposure. If requested, a termination report will be forwarded.

B. INTERNAL MONITORING (BIOASSAYS)

The use of $^{125}I$ in quantities greater than 0.1 mCi may require a thyroid bioassay. A thyroid bioassay is simply a measurement of the iodine activity of the thyroid gland. This activity is representative of the amount of iodine inhaled, ingested or absorbed through the skin. Bioassay procedures will be implemented if the $^{125}I$ quantities exceed the levels given in Table I below:

Table I

| Activity levels* Above Which Bioassay for I-125 or I-131 is Necessary | | |
|---|---|---|
| | Activity Handled in Unsealed form Making Bioassay Necessary** | |
| Type of Operation | Volatile Forms | Non-volatile forms |
| Open room or bench | 0.1 mCi | 1.0 mCi |
| Fume Hood | 1.0 mCi | 10 mCi |
| Glove box | 10 mCi | 100 mCi |

* These quantities apply to both the single quantity handled at any one time or integrated as the total amount of activity introduced into a process over any three (3) month period.

**Quantities may be considered the cumulative amount in process handled by a worker during a 3-month period; e.g., the total quantity introduced into a chemical or physical process over a 3-month period, or on one or more occasions in that period, by opening stock reagent containers from which radioactive iodine may escape. Quantities in the right-hand column may be used when it can be shown that activity in process is always chemically bound and processed in such a manner that I-125 or I-131 will remain in nonvolatile form and diluted to concentrations less than 0.1 mCi/mg of nonvolatile agent. Capsules (such as gelatin capsules given to patients for diagnostic tests) may be considered to contain the radioiodine in non-free form, and bioassay would not be necessary unless a capsule were inadvertently open (e.g., dropped and crushed). However, certain compounds where radioiodine is normally bound are known to release radioiodine when the material is in process, and the left-hand column may then be applicable. In those laboratories working only with I-125 in radioimmunoassay (RIA) kits, the quantities of I-125 are very small and in less volatile forms; thus, bioassay requirements may be judged from the right-hand column. In operations where reagent containers are opened indoors for simple operations such as pouring liquid solutions, the above table does not apply; bioassay should be performed whenever an individual employee handles in open form (e.g., an open bottle or container) more than 50 mCi of I-125 or I-131 at any one time.

Operations involving the routine use of I-125 or I-131 in an open room or bench should be discouraged. Whenever practicable, sealed bottles or containers holding more than 0.1 mCi of I-125 or I-131 should be opened at least initially within hoods having adequate face velocities of 100 feet/minute or more.

The Radiation Safety Officer must approve any procedures that will exceed these levels. If necessary, bioassays will be performed through the University of Nebraska Medical Center Radiation Safety Office.

Routine bioassays for $^{3}H$ are necessary when quantities processed by an individual at any one time or the total amount processed per month exceed those listed in Table II below. Again, the Radiation Safety Officer must approve any procedure that will exceed these levels and, if necessary, bioassays will be performed through the University of Nebraska Medical Center Radiation Safety Office.

Table II

| Activity levels[a] Above Which Tritium Bioassay is Required | | |
|---|---|---|
| Type of Operation | Compounds ( including Nucleotide Precursors) | HTO[b] |
| Process in open room or bench with possible escape of tritium from process vessels. | 10 mCi | 0.1 Ci |
| Processes with possible escape of tritium carries out within a fume hood of adequate design, face velocity, and performance reliability | 100 mCi | 1.0 Ci |
| Processes carried out within gloveboxes that are ordinarily but with possible release of tritium from process vessels and occasional exposure to contaminated box and box leakage. | 1 Ci | 10 Ci |

[a]Activity Levels are considered to be either the amount processed at any one time or put into the process during a one month period.

[b]HTO is a symbol for a water molecule in which a tritium atom (T) is present in place of a normal hydrogen atom (H).

C. INTERNAL MONITORING

Internal monitoring is not done at this facility. (See justification in appendix 7)

## *B-6 Laboratory Surveys*

A. TYPES OF SURVEYS

There are three types of surveys that may be performed depending on the types and quantities of radioactive materials being used.

1) General Use Survey. This is a simple visual check of the laboratory areas to ensure that appropriate warning signs, labels, notices and procedures are being used.

2) Instrument Survey. This is the use of a survey instrument to locate fixed and removable contamination on surfaces, equipment, personnel and clothing.

3) Wipe Survey. This is the use of a filter paper wipe to locate and quantify removable contamination on surfaces, equipment, personnel and clothing.

B. GENERAL USE SURVEY.

Whenever one is working in a radioactive material laboratory, the following items should be checked for and maintained. The Radiation Safety Officer also checks for these items during audits and reports any deficiencies to the Authorized User for correction.

1) Proper posting of radiation use and storage areas with the "Caution - Radioactive Material" sign.

2) Use of proper radioactive waste containers. Containers must be conspicuously labeled with the "Caution - Radioactive Material" warning. The use of unauthorized containers (e.g. coffee cans) to store radioactive material is prohibited unless the labels are defaced or removed.

3) Ensure that radioactive waste is not being deposited in the normal trash.

4) Ensure that food and drink is not stored in refrigerators or cold rooms containing radioactive materials.

5) Ensure that laboratory glassware is not being used for food or drink purposes and food and drink containers are not being used for radioactive materials.

6) Ensure that food or drink is neither prepared nor consumed in an area used for radioactive material. Coffee pots etc. may be used in areas adjacent to radioactive materials areas provided these areas are demonstrated to be free from contamination.

Each Authorized User is responsible for correcting any deficiencies noted above

C. INSTRUMENT SURVEY PROCEDURES

1) Instrument surveys should be performed at the end of each working day. This survey is used for an immediate indication of a problem or to detect contamination prior to a wipe survey.

2) Select an instrument that is appropriate for the nuclide being detected. Check the battery condition and function check the instrument with a suitable check source.

3) Slowly scan surfaces, equipment, personnel and clothing with the probe approximately 1 cm away from the surfaces of the items. In addition, scan the surfaces of all disposal containers and disposal sites. If radiation levels are greater than 2 times the normal background levels, perform a wipe survey. Increased radiation levels in the general area mask lower levels of contamination from instrument detection. For example, a three-fold increase in the background radiation level requires 2-3 times more contamination to be present before the instrument can detect it.

4) If contamination is found, refer to Section B-4.H.

5) After cleaning, a second survey should be performed to ensure that contamination has been removed.

6) ACTION LEVEL: A wipe survey should be performed when an instrument survey indicates exposure rates 2 times background.

D. WIPE SURVEY PROCEDURES.

It is recommended that an instrument survey be performed prior to a wipe survey to minimize the chance of inadvertently spreading the contamination and to identify areas requiring greater attention in wipe surveys. Surveys must be performed at the intervals specified in Table I of this section.

1) Wear gloves.

2) While applying light pressure run a small piece of dry filter paper over the surface being surveyed. A standard area approximating $100cm^2$ should be covered with each wipe to allow comparisons of results.

3) Analyze the sample by using a liquid scintillation counter. The instrument must be sensitive enough to detect 220 dpm (beta, gamma) or 22 dpm (alpha) of the radionuclide on the wipe sample.

4) If contamination above 220 dpm/$100cm^2$ (or 22 dpm/$100cm^2$, respectively) is found, refer to Section B-4.H of this manual.

5) After cleaning, a second survey must be performed to assure that contamination has been removed.

6) ACTION LEVEL:
   a) 220 dpm/100cm$^2$ of beta, gamma
   b) 22 dpm/100cm$^2$ of alpha

To document wipe surveys each lab must have a copy of the survey results keyed to a laboratory diagram.

**Table I - Removable Contamination Survey Frequency for Laboratories**

Amount (mCi) placed into process in a 1-month period. Amount placed into process in a 1-month period means the amount being opened. For example, if a 10 mCi vial is opened to take aliquots out then 10 mCi is considered placed into the process. If a 10 mCi vial is sitting in storage unopened, then it is not placed into the process.

| Radionuclide | Surface Contamination Surveys | | |
|---|---|---|---|
| | Daily or After Use | Weekly | Monthly |
| $^{3}H$ | > 1 Ci | >100 mCi<br>< 1 Ci | <100 mCi |
| $^{32}P$, $^{33}P$, $^{35}S$ | >100 mCi | >10 mCi<br><100 mCi | <10 mCi |
| $^{125}I$ | >10 mCi | >1 mCi<br><10 mCi | <1 mCi |

Note: No surveys are required for areas less than the exempt quantity of a selected radioisotope. See Section C: Appendix 1-6 to determine the exempt quantities of isotopes used at UNO.

## *B-7 Waste Management*

A. GENERAL GUIDELINES

No radioactive waste may be disposed of by conventional methods. This means particularly that solid wastes may not be placed in standard waste containers to be picked up by janitorial services, and liquid waste must be segregated.

No solid waste shall be released from the laboratory area for pickup and disposal prior to suitable deactivation of any infectious agents. No solid waste may contain freestanding liquid.

All radioactivity labels must be removed or defaced from containers and packages prior to disposal as in-house or normal waste.

Waste that is non-radioactive should never be mixed with radioactive waste. Most radionuclides can be detected in waste using a suitable survey instrument (except $^{3}H$). Prior to placing items in the radioactive waste, monitor the waste as follows:

1) Check the radiation detection survey meter for proper operation.

2) Remove any shielding from around the item.

3) Monitor all surfaces of each item.

4) Discard into normal waste only those items that cannot be distinguished from background. Check to make sure that no radiation labels are visible.

5) Items that can be distinguished from background radiation levels must be returned to the storage area for further decay or transferred to the Radiation Safety Officer to decay in the waste storage area.

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

B. LIQUID WASTES.

The options available include:

1) Transfer to RSO in approved containers. Waste liquid may be collected in metal, glass or plastic jugs depending on the chemical profile of the waste. Liquid waste must be segregated according to its:

   a) solubility or dispersability
   b) biological hazard
   c) chemical hazard
   d) radiological half-life

   Any liquid which contains both radioactivity and hazardous material is classified as mixed waste. Mixed waste must meet the requirements of Radiation Safety as well as Hazardous Materials Safety.

   Short half-life waste must be kept separate from long half-life waste. Separate waste into:

   a) short-lived (less than 30 day half-life) - $^{32}P$, $^{33}P$
   b) mid lived (between 30 day and 100 day half-life) - $^{35}S$. $^{125}I$
   c) long lived (greater than 100 day half-life) - $^{3}H$, $^{14}C$

Short and mid lived waste will be stored to decay (10 half-lives) in the designated UNO radioactive waste storage area. The Radiation Safety Officer will keep records indicating the amount, form and age of all waste stored for decay. Authorized users are responsible for segregating and labeling waste containers. Long-lived waste will be absorbed into an approved absorbent material and shipped by a licensed commercial vendor.

2) Release into the sanitary sewer. Liquid radioactive waste may be discharged into the sanitary sewer provided:

a) It is readily soluble or dispersible in water and does not contain hazardous material.
b) It is discharged into a properly labeled "hot sink" followed by sufficient flushing to ensure that the material clears the sink trap and enters the system.
c) The quantity does not exceed the following:

| | Monthly | | Yearly |
|---|---|---|---|
| Carbon-14 | 99 | mCi | 1 Ci per year |
| Hydrogen-3 | 3.3 | Ci | 5 Ci per year |
| Iodine-125 | 6.6 | mCi | 1 Ci per year |
| Phosphorous-32 | 29.7 | mCi | combined total for |
| Phosphorous-33 | 264 | mCi | $^{125}I$, $^{32}P$, $^{35}S$ and |
| Sulfur-35 | 330 | mCi | $^{33}P$ |

In accordance with the established ALARA program, UNO has decided to set these totals at 20% of the above maximum totals.

| | Monthly | | Yearly |
|---|---|---|---|
| Carbon 14 | 19.8 | mCi | .2 Ci per year |
| Hydrogen 3 | .66 | Ci | 1 Ci per year |
| Iodine 125 | 1.32 | mCi | .2 Ci per year |
| Phosphorous 32 | 5.94 | mCi | combined total for |
| Phosphorous 33 | 52.8 | mCi | $^{125}I$, $^{32}P$, $^{33}P$ and |
| Sulfur 35 | 66 | mCi | $^{35}S$ |

If the above limits are approached on a frequent basis (i.e. monthly) contact the RSO to ensure that the University's monthly and yearly limits are not exceeded.

d) All sewer disposal must be recorded on form RSO-8. It is also recommended that a sewer log be kept near the "hot sink".

3) Decay in Storage. Short and mid-lived radionuclides may be decayed for 10 half-lives, monitored for background levels, then released as normal waste.

C. SOLID WASTE

The options available include:

1) Transfer to RSO in approved containers. Solid waste may be collected in plastic waste buckets or plastic bags. Solid waste must be segregated according to its:

   a) biological hazard
   b) chemical hazard
   c) radiological half life

   Any solid waste, which contains both radioactivity and hazardous material, is classified as mixed waste. Mixed waste must meet the requirements of Radiation Safety Manual as well as the Chemical Safety Manual.

   Short half-life waste must be kept separate from long half-life waste. Separate waste into:

   a) short-lived (less than 30 day half-life) - $^{32}P$ and $^{33}P$
   b) mid lived (between 30 day and 100 day half-life) - $^{35}S$ and $^{125}I$
   c) long lived (greater than 100 day half-life) - $^{3}H$, $^{14}C$

   Short and mid lived waste will be stored to decay (10 half-lives) in the designated UNO radioactive waste storage area. The Radiation Safety Officer will keep records indicating the amount, form and age of all waste stored for decay. Authorized users are responsible for segregating and labeling waste containers. Long-lived waste will be shipped by a licensed commercial vendor.

   Sharp items such as syringes, Pasteur pipettes, broken vials etc. shall not be placed in the waste bucket. These shall be placed in a suitable "sharps" container.

   No liquid waste may be mixed with the solid waste unless it can be completely absorbed such that there is no free standing liquid.

2) Decay in Storage. Short and mid-lived radionuclides may be decayed for 10 half-lives, monitored for background levels, then released as normal waste.

D. WASTE LIQUID SCINTILLATION VIALS.

Liquid scintillation vials (LSV) must be segregated from all other wastes. Screw caps must be tightened. Waste LSV shall be placed in cardboard trays and the trays in cardboard cases. LSV containing short and mid-lived radionuclides will be decayed for 10 half-lives then disposed of appropriately. LSV containing long-lived material will be packed into approved barrels and shipped by the licensed commercial vendor, Bionomics Inc. These shipments will be coordinated with the University of Nebraska Medical Center Radiation Safety Office by the RSO.

E. DISPOSAL OF SPECIFIC WASTES CONTAINING SMALL QUANTITIES OF RADIOACTIVE MATERIAL.

0.05 µCi or less of $^{3}H$, $^{14}C$, or $^{125}I$ per gram of medium used for liquid scintillation counting may be disposed without regard to its radioactivity. Note that nothing in this section relieves the user from complying with disposal requirements concerning the chemical, biological or infectious aspects of the waste.

F. COMMERCIAL SHIPPING OF RADIOACTIVE WASTE

The RSO will arrange for the shipment of radioactive waste through a licensed commercial vendor. These shipments will be coordinated with the University of Nebraska Medical Center Radiation Safety Office by the RSO. Authorized Users are responsible for proper segregation, labeling, record keeping and shielding of their waste between shipments.

## SECTION C
## GENERAL INFORMATION

### Appendix 1

ISOTOPE H-3

No activity is to be used in animals without prior written consent from the RSO.

### A. Physical Data

| | |
|---|---|
| Beta Max | 0.0186 MeV (100%) |
| Maximum Range in Air | 0.17 inches |
| Half-Life | 12.28 years |

### B. Radiation Protection Procedures

1) Special Equipment or Procedures

   a) Use transfer pipettes, spill trays or absorbent coverings to confine contamination.
   b) b. Volatile chemical forms above 10 µCi will be handled in a certified fume hood.
   c) Use lab coats and disposable gloves. Select gloves appropriate for chemicals.
   d) Many tritium compounds readily penetrate gloves and skin. Handle these compounds wearing two pairs of gloves and change outer layer frequently.
   e) Tritiated DNA precursors are considered more toxic than tritiated water. However, they are generally less volatile and do not normally present a significantly greater hazard.
   f) Regularly monitor and promptly decontaminate work surfaces to maintain contamination and exposures as low as reasonably achievable.

2) Shielding Requirements

   No shielding required

3) Surface Contamination Survey Schedule

   a) One type of survey to monitor contamination is used. A removable contamination survey utilizing a swipe and liquid scintillation counter will be performed according to the amounts placed into process during a one-month period.

      **See Table I in section B-6 for survey frequencies.**

   b) The contamination limit is 220 dpm/100 $cm^2$ for swipe surveys.

   c) Any area found to be contaminated will be decontaminated and resurveyed to

below the contamination limit of 220 dpm/100cm$^2$.

4) Bioassay Requirements

a) The following activities if handled at any one time or processed in a one-month period requires a bioassay.

HTO (tritiated water) and Other Tritiated Compounds (Including Nucleotide Precursors)
- 100 mCi in open room or bench
- 1000 mCi in a certified hood

b) If a bioassay is required, at least 100 ml of urine must be collected within 72 hours of use.

5) Dosimetry

Millicurie quantities of tritium do not present an external exposure hazard because the low energy betas emitted cannot penetrate the outer dead layer of skin. The critical organ for tritium uptake is the whole body water. Three to four hours after intake, tritiated water is uniformly distributed in all body water. On average, tritiated water is eliminated with a ten-day biological half-life. Elimination rates may be increased by increasing water intake.

## C. Waste Disposal

1) Solid

a) Isolate waste from other nuclides in clearly labeled containers. H-3 may be mixed with C-14 waste.
b) Do not discard items in a radioactive waste receptacle unless you are sure radioactivity is present.
c) Items that do not contain radioactivity may be discarded as normal trash. **All radiation labels are removed or obliterated.**
d) Items that do contain radioactivity must be transferred to Radiation Safety.

2) Liquid

a) Material may be discharged in the sanitary sewer provided it is readily soluble, dispersible in water, and contains no hazardous material.
b) The total quantity of H-3 that can be disposed of in any one day is 10 mCi.
c) A sewer disposal log must be maintained.

3) Vials

a) Vials containing non-biodegradable liquid scintillation cocktail must be transferred to the Radiation Safety Officer.
b) Vials containing biodegradable liquid scintillation cocktail may be disposed of in the sanitary sewer provided it meets 2.a., 2.b., and 2.c.

## D. Survey Meters

Since H-3 is such a weak beta emitter, external detection is not possible. Survey meters are not required. Indicate this on your application.

## E. Personnel Monitoring

As stated previously, external detection of H-3 is not possible since it has such a weak Beta. Film badges are of no use in monitoring for H-3 and therefore not required. Indicate this on your application.

**Hydrogen-3** **12.26 years**

| Years | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 0 | 1.0000 | .9953 | .9906 | .9860 | .9813 | .9721 | .9721 | .9676 | .9630 | .9585 | .9540 | .9495 |
| 1 | .9450 | .9406 | .9362 | .9318 | .9274 | .9230 | .9187 | .9144 | .9101 | .9058 | .9015 | .8973 |
| 2 | .8931 | .8889 | .8847 | .8805 | .8764 | .8723 | .8682 | .8641 | .8600 | .8560 | .8520 | .8480 |
| 3 | .8440 | .8400 | .8361 | .8321 | .8282 | .8243 | .8205 | .8166 | .8128 | .8090 | .8052 | .8014 |
| 4 | .7976 | .7939 | .7901 | .7864 | .7827 | .7790 | .7754 | .7717 | .7681 | .7645 | .7609 | .7573 |
| 5 | .7538 | .7502 | .7467 | .7432 | .7397 | .7362 | .7327 | .7293 | .7259 | .7225 | .7191 | .7157 |
| 6 | .7123 | .7090 | .7056 | .7023 | .6990 | .6957 | .6925 | .6892 | .6860 | .6827 | .6795 | .6763 |
| 7 | .6732 | .6700 | .6669 | .6637 | .6606 | .6575 | .6544 | .6513 | .6483 | .6452 | .6422 | .6392 |
| 8 | .6362 | .6332 | .6302 | .6272 | .6243 | .6214 | .6184 | .6155 | .6126 | .6098 | .6069 | .6040 |
| 9 | .6012 | .5984 | .5956 | .5928 | .5900 | .5872 | .5844 | .5817 | .5790 | .5762 | .5735 | .5708 |

## Appendix 2

ISOTOPE C-14

No activity is to be used in animals without prior written consent from the RSO.

### A. Physical Data

| | |
|---|---|
| Beta Max | 0.156 MeV (100%) |
| Maximum Range in Air | 8.6 inches |
| Maximum Range in Water | 0.01 inches |
| Half-Life | 5,730 years |

### B. Radiation Protection Procedures

1) Special Equipment or Procedures

a) Use transfer pipettes, spill trays or absorbent coverings to confine contamination.
b) Volatile chemical forms will be handled in a certified fume hood.
c) Use lab coats and disposable gloves. Select gloves appropriate for chemicals handled.
d) Regularly monitor and replace gloves as needed.
e) Regularly monitor and promptly decontaminate work surfaces to maintain contamination and exposures as low as reasonably achievable.
f) Special caution should be taken when handling C-14 labeled halogenated acids. These compounds may be incorporated into the skin and give high local doses.

2) Shielding Requirements

Shielding provided by the vial is adequate.

3) Surface Contamination Survey Schedule

a) Two types of surveys to monitor contamination are used.

1) A thin window Geiger Mueller detector will be used to monitor work surfaces after use.
2) A removable contamination survey utilizing a swipe and liquid scintillation counter will be performed according to the amounts placed into process during a one-month period.

**See Table I in Section B-6 for survey frequencies.**

b) The contamination limit is 220 dpm/100 $cm^2$ for swipe surveys. Any indication

above two times normal background on a survey meter is considered to be contamination.

c) Any area found to be contaminated will be decontaminated and resurveyed to below the contamination limit of 220 dpm/100 $cm^2$.

4) Bioassay Requirements

None routinely required. Indicate this on your application.

5) Dosimetry

Millicurie quantities of C-14 do not present a significant external exposure hazard because the low energy betas emitted barely penetrate the outer dead skin layer. The critical organ for uptake of many C-14 labeled carbonates is the bone. The critical organ for uptake of many other C-14 labeled compounds is the fat. Most C-14 labeled compounds are rapidly metabolized and the radionuclide is exhaled as $^{14}CO_2$. Some compounds and their metabolites are eliminated via the urine. Biological half-lives vary from a few minutes to 35 days - ten days being a conservative value for most compounds.

## C. Waste Disposal

1) Solid

a) Isolate waste from other nuclides in clearly labeled containers. C-14 may be mixed with H-3 waste.
b) Do not discard items in a radioactive waste receptacle unless an appropriate survey of the item indicates activity is present. An appropriate survey consists of the following:

1) A low-level thin window survey instrument is utilized.
2) All shielding is removed from the item before surveying.
3) The item is monitored in a low background area (less than 0.05 mRem/hr).

c) Items that cannot be distinguished from background may be discarded as normal trash. All radiation labels are removed or obliterated.
d) Items that indicate levels above background must be transferred to Radiation Safety.

2) Liquid

a) Material may be discharged in the sanitary sewer provided it is readily soluble, dispersible in water, and contains no hazardous materials.
b) The total quantity of C-14 that can be disposed of in any one day is 1 mCi.
c) A sewer disposal log must be maintained.

3) Vials

a) Vials containing non-biodegradable liquid scintillation cocktail must be transferred to the Radiation Safety Office.
b) Vials containing biodegradable liquid scintillation cocktail may be disposed of in the sanitary sewer provided it meets 2.a., 2.b., and 2.c.

**D. Survey Meters**

1) A survey meter is required to work with quantities greater than 100 µCi (exempt quantity).

2) A thin end window Geiger-Mueller tube is necessary to detect C-14. These are typically 10% efficient for detecting C-14.

3) The following combinations are considered acceptable to detect C-14. Others are also available.

| | | |
|---|---|---|
| Ludlum | Meter | Model 2, 0-$10^4$ cpm |
| | Probes | Model 44-7 Thin end window G-M Detector<br>Model 44-9 Pancake G-M Detector |
| Bicron | Meter | Surveyor M, 0-$10^6$ cpm |
| | Probes | Model EWGM end window G-M<br>Model PGM Pancake G-M |

**E. Personnel Monitoring**

Since C-14 is strictly a beta emitter less than 250 KeV, no personnel monitoring is required.

## Appendix 3

ISOTOPE P-32

No activity is to be used in animals without prior written consent from the RSO.

### A. Physical Data

| | |
|---|---|
| Beta Max | 1.71 MeV (100%) |
| Maximum Range in Air | 20 feet |
| Maximum Range in Water | 0.3 inches |
| Half-Life | 14.29 days |

### B. Radiation Protection Procedures

1) Special Equipment or Procedures

a) Use transfer pipettes, spill trays or absorbent coverings to confine contamination.
b) Volatile chemical forms above 10 µCi will be handled in a certified fume hood.
c) Use lab coats and disposable gloves. Select gloves appropriate for chemicals handled.
d) Regularly monitor and replace gloves as needed. A high local dose can be received if the material is touched and allowed to remain on the skin or gloves.
e) Regularly monitor and promptly decontaminate work surfaces to maintain contamination and exposures as low as reasonably achievable.
f) Do not work over open containers. Both the hands and face can receive a considerable dose of radiation near an open container.

2) Shielding Requirements

a) Handle millicurie or greater quantities behind Lucite-type shields approximately 0.5 inches thick.
b) Store millicurie or greater quantities of waste behind Lucite type shields approximately 0.5 inches thick and attach 1/8 to 1/4 inch of lead to outside of Lucite.

3) Surface Contamination Survey Schedule

a) Two type of surveys to monitor contamination are used.

1) A thin window Geiger Mueller detector or thin crystal sodium iodide detector will be used to monitor work surfaces after use.
2) A removable contamination survey utilizing a swipe and liquid scintillation counter will performed according to the amounts placed into process during a one-month period.

**See Table I in Section B-6 for survey frequencies.**

b) The contamination is 220 dpm/100 $cm^2$ for swipe surveys. Any indication above two times normal background on a survey meter is considered to be contamination.

c) Any area found to be contaminated will be decontaminated and resurveyed below the contamination limit of 220 dpm/100 $cm^2$.

4) Bioassay Requirements

None routinely required.

5) Dosimetry

The bone is the critical organ for intake of transportable compounds of P-32. Phosphorus metabolism is complex; 30% is rapidly eliminated from the body, 40% possesses a 19-day biological half-life, and the remaining 30% is reduced by radioactive decay. The lung and lower large intestine are the critical organs for inhalation and ingestion, respectively, of non-transportable P-32 compounds.

The high-energy beta emissions can present a substantial skin dose hazard. Multi millicurie quantities of P-32 can produce significant secondary radiation presenting an external exposure hazard.

## C. Waste Disposal

1) Solid

a) Isolate waste from other nuclides in clearly labeled shielded containers.
b) Do not discard items in a radioactive waste receptacle unless an appropriate survey of the item indicates activity is present. An appropriate survey consists of the following:

1) A low-level survey instrument is utilized.
2) All shielding is removed from the item before surveying.
3) The item is monitored in a low background area (less than 0.05 mRem/hr).

c) Items that cannot be distinguished from background may be discarded as normal trash. All radiation labels are removed or obliterated.
d) Items that indicate levels above background must be further decayed or transferred to Radiation Safety.

2) Liquid

a) Material may be discharged in the sanitary sewer provided it is readily soluble, dispersible in water and contains no hazardous materials.
b) The total quantity of P-32 that can be disposed of in any one day is 0.1 mCi.
c) A sewer disposal log must be maintained.

3) Vials

a) Vials containing non-biodegradable liquid scintillation cocktail may not be used unless written approval from the Radiation Safety Officer is obtained.
b) Vials containing biodegradable liquid scintillation cocktail may be disposed of in the sanitary sewer provided it meets 2.a., 2.b., and 2.c.

## D. Survey Meters

1) A survey meter is required to work with quantities greater than 10 µCi (exempt quantity).

2) An end window Geiger-Mueller tube or thin crystal sodium iodide detector is necessary to detect P-32. The thin window G-M is typically 35-40% efficient for detecting P-32. The thin crystal NaI is typically 60% efficient.

3) The following combinations are considered acceptable to detect P-32. Others are also available.

| | | |
|---|---|---|
| Ludlum | Meter | Model 2, 0-$10^4$ cpm |
| | Probes | Model 44-7 Thin end window G-M Detector<br>Model 44-9 Pancake G-M Detector<br>Model 44-3 Low Energy NaI Detector |
| Bicron | Meter | Surveyor M, 0-$10^6$ cpm |
| | Probes | Model EWGM end window G-M<br>Model PGM Pancake G-M<br>Model GILE Low Energy NaI Detector |

## E. Personnel Monitoring

1) Whole body badges are required when any individual will receive or is likely to receive in any period of one calendar quarter an occupational dose to the whole body in excess of 10% of the maximum annual limit (500 mrem).

2) Extremity ring badges are required when any individual will receive or is likely to receive in any period of one calendar quarter an occupational dose to the extremities in excess of 10% of the maximum annual limit (5,000 mrem).

**Phosphorus-32** **14.28 Days**

| Days | Hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 |
| 0 | 1.0000 | .9960 | .9919 | .9879 | .9840 | .9800 | .9760 | .9721 | .9682 | .9642 | .9604 | .9565 |
| 1 | .9526 | .9488 | .9449 | .9411 | .9373 | .9335 | .9298 | .9260 | .9223 | .9186 | .9149 | .9112 |
| 2 | .9175 | .9038 | .9002 | .8965 | .8929 | .8893 | .8857. | .8821 | .8786 | .8750 | .8715 | .8680 |
| 3 | .8645 | .8610 | .8575 | .8541 | .8506 | .8475 | .8438 | .8404 | .8370 | .883 | .8302 | .8269 |
| 4 | .8235 | .8202 | .8169 | .8136 | .8103 | .8070 | .8038 | .8005 | .7973 | .7941 | .7909 | .7877 |
| 5 | .7845 | .7813 | .7782 | .7750 | .7719 | .7688 | .7657 | .7626 | .7595 | .7565 | .7534 | .7504 |
| 6 | .7473 | .7443 | .7413 | .7383 | .7353 | .7324 | .7294 | .7265 | .7235 | .7206 | .7177 | .7148 |
| 7 | .7119 | .7091 | .7062 | .7033 | .7005 | .6977 | .6949 | .6921 | .6893 | .6865 | .6837 | .6809 |
| 8 | .6782 | .6755 | .6727 | .6700 | .6673 | .6646 | .6619 | .6593 | .6566 | .6540 | .6513 | .6437 |
| 9 | .6461 | .6435 | .6409 | .6383 | .6357 | .6331 | .6306 | .6280 | .6255 | .6330 | .6205 | .6179 |
| 10 | .6155 | .6130 | .6105 | .6080 | .6056 | .6031 | .6007 | .5983 | .5959 | .5935 | .5911 | .5887 |
| 11 | .5863 | .5839 | .5816 | .5792 | .5769 | .5746 | .5722 | .5699 | .5676 | .5653 | .5631 | .5608 |
| 12 | .5585 | .5563 | .5540 | .5518 | .5495 | .5473 | .5451 | .5429 | .5407 | .5385 | .5364 | .5342 |
| 13 | .5321 | .5299 | .5278 | .5256 | .5235 | .5214 | .5193 | .5172 | .5151 | .5130 | .5110 | .5089 |
| 14 | 5068 | .5048 | .5028 | .5007 | .4987 | .4967 | .4947 | .4927 | .4907 | .4887 | .4867 | .4848 |
| 15 | .4828 | .4809 | .4789 | .4770 | .4751 | .4732 | .4713 | .4693 | .4675 | .4656 | .4637 | .4618 |
| 16 | .4600 | .4581 | .4562 | .4544 | .4526 | .4507 | .4489 | .4471 | .4453 | .4435 | .4417 | .4399 |
| 17 | .4382 | .4364 | .4346 | .4329 | .4311 | .4294 | .4277 | .4259 | .4242 | .4225 | .4208 | .4191 |
| 18 | .4174 | .4157 | .4140 | .4124 | .4107 | .4090 | .4074 | .4057 | .4041 | .4025 | .4009 | .3992 |
| 19 | .3976 | .3960 | .3944 | .3928 | .3912 | .3897 | .3881 | .3865 | .3850 | .3834 | .3819 | .3803 |
| 20 | .3788 | .3773 | .3757 | .3742 | .3727 | .3712 | .3697 | .3682 | .3667 | .3652 | .3638 | .3623 |
| 21 | .3608 | .3594 | .3579 | .3565 | .3550 | .3536 | .3522 | .3508 | .3493 | .3479 | .3465 | .3451 |
| 22 | .3437 | .3424 | .3410 | .3396 | .3382 | .3369 | .3355 | .3341 | .3328 | .3314 | .3301 | .3288 |
| 23 | .3275 | .3261 | .3248 | .3235 | .3222 | .3209 | .3196 | .3186 | .3170 | .3157 | .3145 | .3132 |
| 24 | .3119 | .3107 | .3094 | .3082 | .3069 | .3057 | .3045 | .3032 | .3020 | .3008 | .2996 | .2984 |
| 25 | .2972 | .2960 | .2948 | .2936 | .2924 | .2912 | .2900 | .2889 | .2877 | .2865 | .2854 | .2842 |
| 26 | .2831 | .2819 | .2808 | .2797 | .2785 | .2774 | .2763 | .2752 | .2741 | .2730 | .2719 | .2708 |
| 27 | .2697 | .2686 | .2675 | .2664 | .2653 | .2643 | .2632 | .2621 | .2611 | .2600 | .2590 | .2579 |
| 28 | .2659 | .2559 | .2548 | .2538 | .2528 | .2517 | .2507 | .2497 | .2487 | .2477 | .2467 | .2457 |
| 29 | .2447 | .2437 | .2427 | .2418 | .2408 | .2398 | .2388 | .2379 | .2369 | .2360 | .2350 | .2341 |

## Appendix 4

ISOTOPE S-35

No activity is to be used in animals without prior written consent from the RSO.

### A. Physical Data

| | |
|---|---|
| Beta Max | 0.167 MeV (100%) |
| Maximum Range in Air | 9.6 inches |
| Half-Life | 87.44 days |

### B. Radiation Protection Procedures

1) Special Equipment or Procedures

a) Use transfer pipettes, spill trays or absorbent coverings to confine contamination.
b) Volatile chemical forms will be handled in a certified fume hood.
c) Use lab coats and disposable gloves. Select gloves appropriate for chemicals handled.
d) Regularly monitor and replace gloves as needed.
e) Regularly monitor and promptly decontaminate work surfaces to maintain contamination and exposures as low as reasonably achievable.
f) S-35 may be difficult to distinguish from C-14 due to very similar beta emissions.

2) Shielding Requirements

Shielding provided by the vial is adequate.

3) Surface Contamination Survey Schedule

a) Two types of surveys to monitor contamination are used.

1) A thin window Geiger Mueller detector will be used to monitor work surfaces after use.
2) A removable contamination survey utilizing a swipe and liquid scintillation counter will be performed according to the amounts placed into process during a one-month period.

**See Table I in Section B-6 for survey frequencies.**

b) The contamination is 220 dpm/100 $cm^2$ for swipe surveys. Any indication above two times normal background on a survey meter is considered to be contamination.

c) Any area found to be contaminated will be decontaminated and resurveyed below the contamination limit of 220 dpm/100 $cm^2$.

4) Bioassay Requirements

None routinely required. Indicate this on your application.

5) Dosimetry

Millicurie quantities of S-35 do not present a significant external exposure hazard because the low energy emissions barely penetrate the outer dead skin layer. The critical organ for S-35 is the whole body. The elimination rate of S-35 depends on the chemical form. Most S-35 labeled compounds are eliminated via the urine. Ninety days is a conservative biological half-life.

## C. Waste Disposal

1) Solid

a) Isolate waste from other nuclides in clearly labeled containers.

b) Do not discard items in a radioactive waste receptacle unless an appropriate survey of the item indicates activity is present. An appropriate survey consists of the following:
   1) A low-level thin window survey instrument is utilized.
   2) All shielding is removed from the item before surveying.
   3) The item is monitored in a low background area (less than 0.05 mRem/hr)

c) Items that cannot be distinguished from background may be discarded as normal trash. All radiation labels are removed or obliterated.

d) Items that indicate levels above background must be further decayed or transferred to Radiation Safety.

2) Liquid

a) Material may be discharged in the sanitary sewer provided it is readily soluble, dispersible in water, and contains no hazardous materials.

b) The total quantity of S-35 that can be disposed of in any one day is 1 mCi.

c) A sewer disposal log must be maintained.

3) Vials

a) Vials containing non-biodegradable liquid scintillation cocktail may not be used unless written approval from the Radiation Safety Officer is obtained.

b) Vials containing biodegradable liquid scintillation cocktail may be disposed of in the sanitary sewer provided it meets 2.a., 2.b., and 2.c.

## D. Survey Meters

1) A survey meter is required to work with quantities greater than 100 µCi (exempt quantity).

2) A thin window Geiger-Mueller tube is necessary to detect S-35. These are typically 10% efficient for detecting S-35.

3) The following combinations are considered acceptable to detect S-35. Others are also available.

| | | |
|---|---|---|
| Ludlum | Meter | Model 2, 0-$10^4$ cpm |
| | Probes | Model 44-7 Thin end window G-M Detector<br>Model 44-9 Pancake G-M Detector |
| Bicron | Meter | Surveyor M, 0-$10^6$ cpm |
| | Probes | Model EWGM end window G-M<br>Model PGM Pancake G-M |

## E. Personnel Monitoring

Since S-35 is strictly a beta emitter less than 250 KeV, no personnel monitoring is required.

**Sulfur-35** **87.9**

**Days**

| Days | 0. | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.0000 | .9961 | .9921 | .9882 | .9844 | .9805 | .9766 | .9728 | .9689 | .9651 |
| 5 | .9613 | .9576 | .9538 | .9500 | .9463 | .9426 | .9389 | .9352 | .9315 | .9278 |
| 10 | .9242 | .9250 | .9169 | .9133 | .9097 | .9061 | .9026 | .8990 | .8995 | .8920 |
| 15 | .8884 | .8849 | .8815 | .8780 | .8745 | .8711 | .8677 | .8643 | .8609 | .8575 |
| 20 | .8541 | .8507 | .8474 | .8441 | .8407 | .8374 | .8341 | .8308 | .8276 | .8243 |
| 25 | .8211 | .8178 | .8146 | .8114 | .8082 | .8050 | .8019 | .7987 | .7956 | .7924 |
| 1 Month | .7893 | .7862 | .7831 | .7800 | .7770 | .7739 | .7709 | .7678 | .7648 | .7618 |
| 5 | .7588 | .7558 | .7529 | .7499 | .7469 | .7440 | .7411 | .7382 | .7353 | .7324 |
| 10 | .7295 | .7266 | .7237 | .7209 | .7181 | .7152 | .7124 | .7096 | .7068 | .7040 |
| 15 | .7013 | .6985 | .6958 | .6930 | .6903 | .6876 | .6849 | .6822 | .6795 | .6768 |
| 20 | .6742 | .6715 | .6689 | .6662 | .6636 | .6610 | .6584 | .6558 | .6532 | .6507 |
| 25 | .6481 | .6455 | .6430 | .6405 | .6380 | .6354 | .6329 | .6305 | .6280 | .6255 |
| 2 Months | .6230 | .6206 | .6182 | .6157 | .6133 | .6109 | .6085 | .6061 | .6037 | .6013 |
| 5 | .5990 | .5936 | .5943 | .5919 | .5896 | .5873 | .5850 | .5827 | .5804 | .5781 |
| 10 | .5758 | .5735 | .5713 | .5690 | .5668 | .5646 | .5623 | .5601 | .5579 | .5557 |
| 15 | .5535 | .5514 | .5492 | .5470 | .5449 | .5427 | .5406 | .5385 | .5364 | .5342 |
| 20 | .5321 | .5300 | .5280 | .5259 | .5238 | .5218 | .5197 | .5177 | .5156 | .5136 |
| 25 | .5116 | .5096 | .5075 | .5056 | .5036 | .5016 | .4996 | .4976 | .4957 | .4937 |
| 3 Months | .4918 | .4899 | .4879 | .4860 | .4841 | .4822 | .4803 | .4784 | .4765 | .4746 |
| 5 | .4728 | .4709 | .4691 | .4672 | .4654 | .4635 | .4617 | .4599 | .4581 | .4563 |
| 10 | .4545 | .4527 | .4509 | .4492 | .4474 | .4456 | .4439 | .4421 | .4404 | .4387 |
| 15 | .4369 | .4352 | .4335 | .4318 | .4301 | .4284 | .4267 | .4250 | .4234 | .4217 |
| 20 | .4200 | .4184 | .4167 | .4151 | .4135 | .4118 | .4102 | .4086 | .4070 | .4054 |
| 25 | .4038 | .4022 | .4006 | .3990 | .3975 | .3959 | .3944 | .3928 | .3913 | .3897 |
| 4 Months | .3882 | .3867 | .3851 | .3836 | .3821 | .3806 | .3791 | .3776 | .3761 | .3747 |

## Appendix 5

ISOTOPE I-125

No activity is to be used in animals without prior written consent from the RSO.

### A. Physical Data

| | |
|---|---|
| Half-Life | 60.14 days |
| Gamma | 0.035 MeV (6.5%) |
| K1 x-ray | 0.027 MeV (112.0%) |
| K2 x-ray | 0.031 MeV (25.4%) |
| Unshielded Exposure Rate at 1 foot from 1 mCi | 1.5 mr/hr |
| Half-Value Layer | 0.02 mm Lead |

### B. Radiation Protection Procedures

1) Special Equipment or Procedures

a) Use transfer pipettes, spill trays or absorbent coverings to confine contamination.
b) Iodine can be very volatile in unbound forms or at low pH. Volatile chemical forms above 10 µCi will be handled in a certified fume hood.
c) Use lab coats and two pairs of disposable gloves. Select gloves appropriate for chemicals handled.
d) Regularly monitor and replace gloves.
e) Regularly monitor and promptly decontaminate work surfaces to maintain contamination and exposures as low as reasonably achievable.

2) Shielding Requirements

Store millicurie or greater quantities in containers surrounded by at least 0.1 inch lead.

3) Surface Contamination Survey Schedule

a) Two types of surveys to monitor contamination are used.

1) A thin crystal NaI detector will be used to monitor work surfaces after use.
2) A removable contamination survey utilizing a swipe and a gamma or liquid scintillation counter will be performed according to amounts placed into process during a one-month period.

**See Table I in Section B-6 for survey frequencies.**

b) The contamination is 220 dpm/100 $cm^2$ for swipe surveys. Any indication above two times normal background on a survey meter is considered to be contamination.

c) Any area found to be contaminated will be decontaminated and resurveyed below the contamination limit of 220 dpm/100 $cm^2$.

4) Bioassay Requirements

a) The following activities if handled at any one time or processed in a three-month period requires a thyroid bioassay.

| | | |
|---|---|---|
| Volatile Form | 0.1 mCi<br>1.0 mCi | - in an open room or bench<br>- in a certified hood |
| Non-Volatile Form | 1.0 mCi<br>10.0 mCi | - in an open room or bench<br>- in a certified hood |

b) When required, bioassays must be performed at a minimum on a quarterly basis. If more frequent monitoring is desired, it must be performed within 6 to 72 hours after suspected uptake.

5) Dosimetry

The thyroid is the critical organ for I-125 uptake. Individual uptake and metabolism vary over a wide range. The thyroid may be assumed to accumulate 30% of soluble radioiodine uptake to the body and retain iodine with a 138-day biological half-life. All radioiodine in the body can be assumed to be eliminated via the urine.

## C. Waste Disposal

1) Solid

a) Isolate waste from other nuclides in clearly labeled shielded containers.

b) Do not discard items in a radioactive waste receptacle unless an appropriate survey of the item indicates activity is present. An appropriate survey consists of the following:
   1) A low-level thin crystal NaI survey instrument is utilized.
   2) All shielding is removed from the item before surveying.
   3) The item is monitored in a low background area (less than 0.05 mRem/hr).

c) Items that cannot be distinguished from background may be discarded as normal trash. All radiation labels are removed or obliterated.

d) Items that indicate levels above background must be transferred to the Radiation Safety Officer.

2) Liquid

a) Material may be discharged in the sanitary sewer provided it is readily soluble, dispersible in water and contains no hazardous materials.

b) The total quantity of I-125 that can be disposed of in any one day is 10 µCi.

c) A sewer disposal log must be maintained.

3) Vials

a) Vials containing non-biodegradable liquid scintillation cocktail may not be used unless written approval from the Radiation Safety Officer is obtained.

b) Vials containing biodegradable liquid scintillation cocktail may be disposed of in the sanitary sewer provided it meets 2.a., 2.b., and 2.c.

## D. Survey Meters

1) A survey meter is required to work with quantities greater than 1 µCi (exempt quantity).

2) A thin crystal sodium iodide detector is necessary to detect I-125. This probe is at least 38% efficient or 675,000 cpm/mr/hr for I-125.

3) The following combinations are considered acceptable to detect I-125. Others are also available.

| | | |
|---|---|---|
| Ludlum | Meter | Model 3, 0-$10^4$ cpm |
| | Probes | Model 44-3 Low Energy NaI Detector |
| Bicron | Meter | Surveyor M, 0-$10^6$ cpm |
| | Probes | Model GILE Low Energy NaI Detector |

## E. Personnel Monitoring

1) Whole body badges are required when any individual will receive or is likely to receive in any period of one calendar quarter an occupational dose to the whole body in excess of 10% of the maximum annual limit (500 mrem).

2) Extremity ring badges are required when any individual will receive or is likely to receive in any period of one calendar quarter an occupational dose to the extremities in excess of 10% of the maximum annual limit (5,000 mrem).

**Iodine-125**
**60.2 Days**

| Days | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Days | 0 | .5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 |
| 0 | 1.0000 | .9943 | .9886 | .9829 | .9772 | .9716 | .9660 | .9605 | .9550 | .9495 |
| 5 | .9441 | .9386 | .9332 | .9279 | .9226 | .9173 | .9120 | .9068 | .9016 | .8964 |
| 10 | .8912 | .8861 | .8810 | .8760 | .8710 | .8660 | .8610 | .8560 | .8511 | .8462 |
| 15 | .7943 | .7898 | .7852 | .7807 | .7762 | .7718 | .7673 | .7629 | .7586 | .7542 |
| 20 | .7943 | .7898 | .7852 | .7807 | .7762 | .7718 | .7673 | .7629 | .7586 | .7542 |
| 25 | .7499 | .7456 | .7413 | .7370 | .7328 | .7286 | .7244 | .7203 | .7161 | .7120 |
| 1 Month | .7079 | .7039 | .6998 | .6958 | .6918 | .6878 | .6839 | .6800 | .6761 | .6722 |
| 5 | .6683 | .6645 | .6607 | .6569 | .6531 | .6494 | .6456 | .6419 | .6382 | .6346 |
| 10 | .6309 | .6273 | .6237 | .6201 | .6166 | .6130 | .6095 | .6060 | .6025 | .5991 |
| 15 | .5956 | .5922 | .5888 | .5854 | .5821 | .5787 | .5754 | .5721 | .5688 | .5656 |
| 20 | .5623 | .5591 | .5559 | .5527 | .5495 | .5464 | .5432 | .5401 | .5370 | .5339 |
| 25 | .5309 | .5278 | .5248 | .5218 | .5188 | .5158 | .5128 | .5099 | .5070 | .5040 |
| 2 Months | .5012 | .4983 | .4954 | .4926 | .4897 | .4869 | .4841 | .4814 | .4786 | .4758 |
| 5 | .4731 | .4704 | .4677 | .4650 | .4623 | .4597 | .4571 | .4544 | .4518 | .4492 |
| 10 | .4466 | .4441 | .4415 | .4390 | .4365 | .4340 | .4315 | .4290 | .4265 | .4241 |
| 15 | .4217 | .4192 | .4168 | .4144 | .4144 | .4097 | .4073 | .4050 | .4027 | .4004 |
| 20 | .3981 | .3958 | .3935 | .3913 | .3890 | .3868 | .3846 | .3823 | .3802 | .3780 |
| 25 | .3758 | .3736 | .3715 | .3694 | .3672 | .3651 | .3630 | .3610 | .3589 | .3568 |
| 3 Months | .3548 | .3527 | .3507 | .3487 | .3467 | .3447 | .3427 | .3408 | .3388 | .3369 |
| 5 | .3349 | .3330 | .3311 | .3292 | .3273 | .3254 | .3236 | .3217 | .3199 | .3180 |
| 10 | .3162 | .3144 | .3126 | .3108 | .3090 | .3072 | .3055 | .3037 | .3020 | .3002 |
| 15 | .2985 | .2968 | .2951 | .2934 | .2917 | .2900 | .2884 | .2867 | .2851 | .2834 |
| 20 | .2818 | .2802 | .2786 | .2770 | .2754 | .2738 | .2722 | .2707 | .2691 | .2676 |
| 25 | .2660 | .2645 | .2630 | .2615 | .2600 | .2585 | .2570 | .2555 | .2541 | .2526 |
| 4 Months | .2512 | .2497 | .2483 | .2469 | .2454 | .2440 | .2426 | .2412 | .2398 | .2385 |

## Appendix 6

ISOTOPE P-33

No activity is to be used in animals without prior written consent from the RSO.

### A. Physical Data

| | |
|---|---|
| Beta Max | 0.249 MeV (100%) |
| Maximum Range in Air | 19 inches |
| Half-Life | 25.4 days |

### B. Radiation Protection Procedures

1) Special Equipment or Procedures

a) Use transfer pipettes, spill trays or absorbent coverings to confine contamination.
b) Volatile chemical forms above 10 µCi will be handled in a certified fume hood.
c) Use lab coats and disposable gloves. Select gloves appropriate for chemicals handled.
d) Regularly monitor and replace gloves as needed. A high local dose can be received if the material is touched and allowed to remain on the skin or gloves.
e) Regularly monitor and promptly decontaminate work surfaces to maintain contamination and exposures as low as reasonably achievable.
f) Do not work over open containers. Both the hands and face can receive a considerable dose of radiation near an open container.

2) Shielding Requirements

a) Handle millicurie or greater quantities behind Lucite-type shields approximately 0.5 inches thick.
b) Store millicurie or greater quantities behind Lucite-type shields approximately 0.5 inches thick.

3) Surface Contamination Survey Schedule

a) Two types of surveys to monitor contamination are used.
   1) A thin window Geiger Mueller detector or thin crystal sodium iodide detector will be used to monitor work surfaces after use.
   2) A removable contamination survey utilizing a swipe and liquid scintillation counter will be performed according to the amounts placed into process during a one-month period.

**See Table I in Section B-6 for survey frequencies.**

b) The contamination is 220 dpm/100 $cm^2$ for swipe surveys. Any indication above two times normal background on a survey meter is considered to be contamination.

c) Any area found to be contaminated will be decontaminated and resurveyed below the contamination limit of 220 dpm/100 $cm^2$.

4) Bioassay Requirements

None Routinely Required

5) Dosimetry

The bone is the critical organ for intake of transportable compounds of P-33. Phosphorus metabolism is complex; 30% is rapidly eliminated from the body, 40% possesses a 19-day biological half-life, and the remaining 30% is reduced by radioactive decay. The lung and lower large intestine are the critical organs for inhalation and ingestion, respectively, of non-transportable P-33 compounds.

Multi millicurie quantities of P-33 do not present a significant external exposure hazard because the low-energy betas emitted barely penetrate gloves and the outer dead layer of skin.

## C. Waste Disposal

1) Solid

a) Isolate waste from other nuclides in clearly labeled shielded containers.

b) Do not discard items in a radioactive waste receptacle unless an appropriate survey of the item indicates activity is present. An appropriate survey consists of the following:
   1) A low-level survey instrument is utilized.
   2) All shielding is removed from the item before surveying.
   3) The item is monitored in a low background area (less than 0.5 mRem/hr).

c) Items that cannot be distinguished from background may be discarded as normal trash. All radiation labels are removed or obliterated.

d) Items that indicate levels above background must be further decayed or transferred to the Radiation Safety Officer.

2) Liquid

a) Material may be discharged in the sanitary sewer provided it is readily soluble, dispersible in water and contains no hazardous materials.
b) The total quantity of P-33 which can be disposed of in any one year is 1Ci

combined total with P-32, S-35, and I-125.

c) A sewer disposal log must be maintained.

3) Vials

a) Vials containing non-biodegradable liquid scintillation cocktail must be transferred to the Radiation Safety Office.

b) Vials containing biodegradable liquid scintillation cocktail may be disposed of in the sanitary sewer provided it meets 2.a., 2.b., and 2.c.

## D. Survey Meters

1) A survey meter is required to work with quantities greater than exempt quantity.

2) A thin crystal sodium iodide detector is necessary to detect I-125. This probe is at least 38% efficient or 675,000 cpm/mr/hr for I-125.

3) The following combinations are considered acceptable to detect I-125. Others are also available.

| | | |
|---|---|---|
| Ludlum | Meter | Model 2, 0-$10^4$ cpm |
| | Probes | Model 44-7 Thin end window G-M Detector<br>Model 44-9 Pancake G-M Detector |
| Bicron | Meter | Surveyor M, 0-$10^6$ cpm |
| | Probes | Model EWGM end window G-M<br>Model PGM Pancake G-M |

## E. Personnel Monitoring

1) Whole body badges are required when any individual will receive or is likely to receive in any period of one calendar quarter an occupational dose to the whole body in excess of 10% of the maximum annual limit (500 mrem).
2) Extremity ring badges are required when any individual will receive or is likely to receive in any period of one calendar quarter an occupational dose to the extremities in excess of 10% of the maximum annual limit (5,000 mrem).

**Phosphorous-33** **25.4 Days**

| Days | Hours | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 |
| 0 | 1.000 | 0.998 | .0995 | 0.993 | 0.991 | 0.989 | 0.986 | 0.984 | 0.982 | 0.980 | 0.978 | 0.975 |
| 1 | 0.973 | 0.971 | 0.969 | 0.966 | 0.964 | 0.962 | 0.960 | 0.958 | 0.956 | 0.953 | 0.951 | 0.949 |
| 2 | 0.947 | 0.945 | 0.943 | 0.940 | 0.938 | 0.936 | 0.934 | 0.932 | 0.930 | 0.928 | 0.926 | 0.924 |
| 3 | 0.921 | 0.919 | 0.917 | 0.915 | 0.913 | 0.911 | 0.909 | 0.907 | 0.905 | 0.903 | 0.901 | 0.899 |
| 4 | 0.897 | 0.895 | 0.893 | 0.891 | 0.888 | 0.886 | 0.884 | 0.882 | 0.880 | 0.878 | 0.876 | 0.874 |
| 5 | 0.872 | 0.870 | 0.869 | 0.867 | 0.865 | 0.863 | 0.861 | 0.859 | 0.857 | 0.855 | 0.853 | 0.851 |
| 6 | 0.849 | 0.847 | 0.845 | 0.843 | 0.841 | 0.839 | 0.837 | 0.836 | 0.834 | 0.832 | 0.830 | 0.828 |
| 7 | 0.826 | 0.824 | 0.822 | 0.821 | 0.819 | 0.817 | 0.815 | 0.813 | 0.811 | 0.809 | 0.808 | 0.806 |
| 8 | 0.804 | 0.802 | 0.800 | 0.798 | 0.797 | 0.795 | 0.793 | 0.791 | 0.789 | 0.788 | 0.786 | 0.784 |
| 9 | 0.782 | 0.780 | 0.779 | 0.777 | 0.775 | 0.773 | 0.772 | 0.770 | 0.768 | 0.766 | 0.765 | 0.763 |
| 10 | 0.761 | 0.759 | 0.758 | 0.756 | 0.754 | 0.753 | 0.751 | 0.749 | 0.747 | 0.746 | 0.744 | 0.742 |
| 11 | 0.741 | 0.739 | 0.737 | 0.736 | 0.734 | 0.732 | 0.731 | 0.729 | 0.727 | 0.726 | 0.724 | 0.722 |
| 12 | 0.721 | 0.719 | 0.718 | 0.716 | 0.714 | 0.713 | 0.711 | 0.709 | 0.708 | 0.706 | 0.705 | 0.703 |
| 13 | 0.701 | 0.700 | 0.698 | 0.697 | 0.695 | 0.693 | 0.692 | 0.690 | 0.689 | 0.687 | 0.686 | 0.684 |
| 14 | 0.683 | 0.681 | 0.679 | 0.678 | 0.676 | 0.675 | 0.673 | 0.672 | 0.670 | 0.669 | 0.667 | 0.666 |
| 15 | 0.664 | 0.663 | 0.661 | 0.660 | 0.658 | 0.657 | 0.655 | 0.654 | 0.652 | 0.651 | 0.649 | 0.648 |
| 16 | 0.646 | 0.645 | 0.643 | 0.642 | 0.640 | 0.639 | 0.638 | 0.636 | 0.635 | 0.633 | 0.632 | 0.630 |
| 17 | 0.629 | 0.627 | 0.626 | 0.625 | 0.623 | 0.622 | 0.620 | 0.619 | 0.618 | 0.616 | 0.615 | 0.613 |
| 18 | 0.612 | 0.611 | 0.609 | 0.608 | 0.606 | 0.605 | 0.604 | 0.602 | 0.601 | 0.600 | 0.598 | 0.597 |
| 19 | 0.595 | 0.594 | 0.593 | 0.591 | 0.590 | 0.589 | 0.587 | 0.586 | 0.585 | 0.583 | 0.582 | 0.581 |
| 20 | 0.579 | 0.578 | 0.577 | 0.576 | 0.574 | 0.573 | 0.572 | 0.570 | 0.569 | 0.568 | 0.566 | 0.565 |
| 21 | 0.564 | 0.563 | 0.561 | 0.560 | 0.559 | 0.557 | 0.556 | 0.555 | 0.554 | 0.552 | 0.551 | 0.550 |
| 22 | 0.549 | 0.547 | 0.546 | 0.545 | 0.544 | 0.542 | 0.514 | 0.540 | 0.539 | 0.538 | 0.536 | 0.535 |
| 23 | 0.534 | 0.533 | 0.531 | 0.530 | 0.529 | 0.528 | 0.527 | 0.525 | 0.524 | 0.523 | 0.522 | 0.521 |
| 24 | 0.520 | 0.518 | 0.517 | 0.516 | 0.515 | 0.514 | 0.513 | 0.511 | 0.510 | 0.509 | 0.508 | 0.507 |
| 25 | 0.506 | 0.504 | 0.503 | 0.502 | 0.501 | 0.500 | 0.499 | 0.498 | 0.496 | 0.495 | 0.494 | 0.493 |
| 26 | 0.492 | 0.491 | 0.490 | 0.489 | 0.488 | 0.486 | 0.485 | 0.484 | 0.483 | 0.482 | 0.481 | 0.48 |
| 27 | 0.479 | 0.478 | 0.477 | 0.475 | 0.474 | 0.473 | 0.472 | 0.471 | 0.470 | 0.469 | 0.468 | 0.467 |
| 28 | 0.466 | 0.465 | 0.464 | 0.463 | 0.462 | 0.461 | 0.46 | 0.458 | 0.457 | 0.456 | 0.455 | 0.454 |
| 29 | 0.453 | 0.452 | 0.451 | 0.450 | 0.449 | 0.448 | 0.447 | 0.446 | 0.445 | 0.444 | 0.443 | 0.442 |
| 30 | 0.441 | 0.44 | 0.439 | 0.438 | 0.437 | 0.436 | 0.435 | 0.434 | 0.433 | 0.432 | 0.431 | 0.43 |
| 2 Months | 0.195 | 0.194 | 0.194 | 0.193 | 0.193 | 0.192 | 0.192 | 0.191 | 0.191 | 0.191 | 0.190 | 0.190 |
| 3 Months | 0.086 | 0.086 | 0.085 | 0.085 | 0.085 | 0.085 | 0.085 | 0.084 | 0.084 | 0.084 | 0.084 | 0.084 |
| 4 Months | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 |
| 5 Months | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 |
| 6 Months | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 |

## Appendix 7

JUSTIFICATION FOR NOT DOING INTERNAL MONITORING

Inhalation - No volatiles are used in this facility, so the chances of accidental inhalation of radioisotopes is minimal. In addition, all transfers of radioactive material are done in a hood further reducing the possibility of accidental inhalation. After initial dilution which is done under strictly controlled conditions, the activity of radioactive material used in the laboratory in any container, at any one time is never greater than 100µCi for P-32, P-33, S-35, H-3 and 5 µCi for I-125. Using 10% of the total volume as the worst possible inhalation exposure in the laboratory, the following ALI values have been calculated.

P-32 - 10 µCi / 9E+2 µCi X 5000 mrem = 55.6 mrem

P-33 - 10 µCi / 8E+3 µCi X 5000 mrem = 6.25 mrem

S-35 - 10 µCi / 2E+4 µCi X 5000 mrem = 2.5 mrem

H-3 - 10 µCi / 8E+4 µCi X 5000 mrem = 0.65 mrem

I-125 - Thyroid 0.5 µCi / 6E+1 µCi X 50,000 mrem = 416.7 mrem

These values are well below the 10% of 5 Rem or 500 mrem for P-32, P-33, S-35 and H-3 and 10% of 50 Rem or 50,000 mrem for I-125, that require monitoring for internal inhalation.

Ingestion - No eating, drinking, smoking or application of cosmetics are allowed in areas where radioactive material is used. No pipetting by mouth is allowed. In labs where food is allowed, eating areas are clearly defined and no food or drink is allowed outside of this area nor are radioactive materials allowed inside the area. After initial dilution, which is done under strictly controlled conditions, the activity of radioactive material used in the laboratory in any container, at any one time, is never greater than 100µCi for P-32, S-35, H-3 and 5 µCi I-125. Using 50% of the total volume as the worst possible ingestion exposure in the laboratory, the following ALI values have been calculated:

P-32 - 50 µCi / 6E+2 µCi X 5000 mRem = 416.7 mrem

P-33 - 50 µCi / 6E+3 µCi X 5000 mRem = 41.7 mrem

S-35 - 50 µCi / 6E+3 µCi X 5000 mRem = 41.7 mrem

H-3 - 50 µCi / 8E+4 µCi X 5000 mRem = 3.125 mrem

I-125 - Thyroid 2.5 µCi / 4E+1 µCi X 50,000 mrem = 3,125 mrem

These values are well below the 10% of 5 Rem or 500 mrem for P-32, P-33, S-35 and H-3 and 10% of 50 Rem or 50,000 mrem for I-125, that require monitoring for internal inhalation.