



RADIATION SAFETY MANUAL

ABSTRACT

This RADIATION SAFETY MANUAL provides the official statement by the University of North Texas of the policies, procedures, and regulations governing the radiation safety program.

Risk Management Services

FOREWORD

Radiation safety is an essential component of our university's environment because radioisotopes and other radiation sources are used in research and instruction. Since the majority of our people are unaware of potential radiation hazards, strict adherence to federal, state and university regulations is mandatory. This is both a legal and moral responsibility of the University and those who use radiation sources.

The University has been granted a Radioactive Materials License L00101 and Certificate of Registration R04611 by the Texas Department of Health for use in research, development, and instruction. These documents require that we establish and follow an effective radiation safety program. The Radiation Safety Committee of the University of North Texas has been delegated this responsibility, and this Manual sets forth the policies and procedures established by that Committee and approved by the Texas Department of State Health Services.

It is the responsibility of all within the university community who are involved in any way with ionizing radiation work to familiarize themselves thoroughly with its requirements and all applicable federal and state regulations. Constant vigilance is required to prevent negligent use of radioactive materials and/or exposure to radiation. Thereby, the Office of the President of the University of North Texas fully supports the radiation safety program and directs that the Office of Radiation Safety and the Radiation Safety Committee conduct this program in a manner that enforces complete compliance with the Texas Regulations for the Control of Radiation, the University's Radioactive Materials License L00101 and the Certificates of Registration R004611 and R19956.

This RADIATION SAFETY MANUAL provides the official statement by the University of North Texas of the policies, procedures, and regulations governing the radiation safety program.

Neal J. Smatresk Ph.D.
President
University of North Texas

NOTICE

The purpose of this Manual is to supplement federal, state and local regulations for the control of radiation and in no case is it intended to replace those regulations. Should it occur that existing future federal or state regulations are found to differ from the requirements contained in this Manual, those regulations will take precedence.

In the event of an alleged violation of the regulations set forth in this Manual, or those prescribed in the 25 TEXAS ADMINISTRATIVE CODE Part 289:Texas Regulations for the Control of Ionizing Radiation, the person noting the alleged violation should immediately contact the University Radiation Safety Officer or a member of the Radiation Safety Committee.

The Radiation Safety Officer and/or the Committee may request that the alleged violator meet with the Committee and discuss the violation for purposes of clarifying the policies for using radiation and to explain the hazards associated with the violation. If the alleged violator shows a flagrant disregard for proper operating procedures, the Committee may then revoke the authorized user's privilege of using radiation materials or radiation producing devices.

Additions and alterations to these regulations may be made by the Radiation Safety Committee with the approval of the State of Texas Department of Health/Bureau of Radiation Control, when in the opinion of the Committee such additions and alterations are necessary for the protection of the University, its employees and students.

A copy of this Manual is on file at the State of Texas Department of State Health Services/Radiation Control, Austin, Texas.

Emergency Telephone Numbers

Department	Phone Number
Radiation Safety Officer (RSO)	940-565-4196
X-ray and Laser Safety Officer	940-565-4196
Risk Management	940-565-2109
University Police	940-565-3000
University Health Center	940-565-2333
UNT Fire and Emergency	9-911
Denton Fire Department	9-911

In case of incidents involving unusual radiation exposure or laboratory accidents involving radioactive materials, all personnel are required to notify the Radiation Safety Officer immediately.

ANY QUESTIONS OR CONCERNS PERTAINING TO THE CONDUCT OF THE RADIATION SAFETY PROGRAM AT THE UNIVERSITY OF NORTH TEXAS SHOULD BE DIRECTED TO RISK MANAGEMENT SERVICES AT 940-565-2109.

After hours or weekends, the University Police (940-565-3000) will assist in contacting the Radiation Safety Officer.

RECORD OF CHANGES

Change #	Date of Change	Change Entered by	Description
25-01	02/2025	Todd Germain	Adding Record of Changes, changing font, contact list/information updated

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1 RADIATION SAFETY PROGRAM ADMINISTRATION

1.1 THE RADIATION SAFETY COMMITTEE (RSC)

The Radiation Safety Committee (RCS), appointed by the Senior Vice President for Finance and Administration directs the University's Radiation Safety Program. The term of the Chair of the Radiation Safety Committee and each member shall be three years, and members shall be eligible for re-appointment. Members of the RCS includes the Chair, the Associate Vice President of Research and Innovation or a representative , faculty members who are knowledgeable about the ionizing and non-ionizing radiation, the Radiation Safety Officer (RSO) and other safety professionals at the discretion of the RSO.

Authorities and Responsibilities of the Radiation Safety Committee

- a. Establish procedures and standard of practice for the Radiation Safety Program
- b. Establish procedures designed to protect faculty, staff, students, visitors and the public from the harmful effect of radioactive material and ionizing radiation devices.
- c. Provide approval/disapproval of new types or modalities of use of radioactive materials and radiation-producing equipment.
- d. Review radiation safety incidents, issues, and violations, and recommend corrective actions.
- e. Review a summary of the occupational radiation dose records and recommendations on ways to maintain doses as low as reasonably achievable (ALARA).
- f. Review the Radiation Safety Program to determine that all activities are being conducted in accordance with radiation safety policy, license conditions, and regulatory requirements.

1.2 THE RADIATION SAFETY OFFICER (RSO)

1.2.1 *Appointment of Radiation Safety Officer*

- a. The Radiation Safety Officer shall be a person qualified by training and experience to give guidance and assistance in the safe use of ionizing radiation.
- b. The Radiation Safety Officer is designated by the President of the University to carry out the policies of the Radiation Safety Committee. The Radiation Safety Officer will advise the Committee in matters of radiation safety.

1.2.2 *Authority of the Radiation Safety Officer*

- a. The RSO shall suspend as rapidly as possible any operation causing an excessive radiological hazard and exposure.
- b. The RSO shall suspend any operation that violates, or that may result in the violation of, the policies set forth in this manual.
- c. Prepares license and registration applications, amendment applications, and required reports/records as well as acting as the contact point for all correspondence with State and Federal Radiation Health Agencies.

1.2.3 Duties of the Radiation Safety Officer

- a. The Radiation Safety Officer is available to assist and advise Authorized Users of ionizing radiation on the University campus, and to ensure that all ionizing radiation is used in accordance with the policies approved by the Radiation Safety Committee.
- b. The RSO ensures that proper surveys conducted in all authorized locations where ionizing radiation is used, and that appropriate records are maintained.
- c. RSO maintains all records required by state and federal regulations which includes but not limited to the following:
 - personnel dosimetry records
 - radioactive waste disposal
 - radioactive materials inventory
 - radiological instrument calibration
 - leak tests on sealed sources
 - radiation safety surveys
 - Radioactive waste disposal
- d. The RSO shall provide an individual radiation exposure record within 30 days of request from any individual whose exposure was monitored.
- e. The RSO provides training for users and potential users of ionizing radiation.

1.3 THE PRINCIPAL INVESTIGATOR (PI)

Principal Investigators are those individuals listed by name on the UNT's radioactive material license. Any person who wishes to use radioactive materials on University property must submit an application to the Radiation Safety Committee via the Radiation Safety Officer.

The application may be approved, provided that the prospective user provides evidence of training, experience, facilities and equipment necessary to possess the radioactive materials in such a manner that:

- Personnel exposure to ionizing radiation will be kept As Low As Reasonably Achievable (ALARA).
- The PI will comply with the policies set forth in this manual and the radiation safety program.
- No state or federal regulations will be violated.

1.3.1 Requests for Possession and Use of Radiative Materials

- a. Only full-time members of the Academic Faculty will be approved as a Principal Investigator of radioactive material.
- b. Submits applications to possess and use radioactive materials or sources of radiation to the Office of Radiation Safety for review by the Radiation Safety Committee. No work may be performed until authorization is received.
- c. List each Authorized Users who will be working with radioactive material under the supervision of the PI.

- d. A completed statement of training and experience must be attached for each individual.

1.3.2 Duties of the Principal Investigator

It is the responsibility of the PI to:

- a. Ensure that all personnel under their direction observe the policies in this manual.
- b. Provide adequate planning before an experiment is performed, the investigator should determine the type and amount of radiation or radioactive material to be used. Trial runs should be made whenever practical to determine proper procedures and to evaluate necessary radiation protection and handling.
- c. Instructs all their staff and subordinates in the use of safe techniques and in the application of approved radiation protection, and verifying that all their radiation workers have had the necessary training and certification prior to beginning work with radioactive materials and/or radiation producing devices.
- d. Make available appropriate radiation safety procedures and policies, and the appropriate personal protective equipment (PPE). These should be accessible in the authorized use location.
- e. Ensure that radiological surveys are completed and records maintained as required by the Radiation Safety Officer and this manual.
- f. Keep an up-to-date inventory of all radioactive materials in their possession.
- g. Ensure that security of radioactive materials is adequate to prevent unauthorized access.
- h. Properly prepare and store radioactive waste material for disposal as described in this manual.
- i. Post proper radiation signs and labels as described in this manual.
- j. Treat all authorized use locations as radioactive materials areas and comply with the associated safety requirements.
- k. Ensure that neither radioactive materials nor contaminated equipment is removed from the radioactive materials area, unless proper procedures are followed as described in this manual.
- l. Ensure that nothing is removed from an authorized use location to an unrestricted area, until the materials have been surveyed, found to be free of contamination, and all radioactive warning labels removed.

1.3.3 Absences of the Principal Investigation

- a. A PI on faculty developmental leave or absent for a period greater than 30days shall assign authority and/or responsibility for his/her program to another Principal Investigator or Authorized User who will be in charge of the laboratory in his/her absence.
 - The PI must establish the following prior to his/her absence
 - An individual who accepts in writing the responsibility for the laboratory.
 - The Radiation Safety Committee must approve the individual.
 - The alternative may be utilized for a period not exceeding 12 months.

- Provide a contact information (an email address and a telephone number).
- b. In an event of employment termination, the PI must provide the RSO with the following radiological records.
 - All radioactive material in their possession
 - Close out survey of all authorized use locations
 - All radioactive waste material for disposal
 - All radiological records in their possession

1.3.4 Inactive Status

A Principal Investigator who does not possess any radioactive materials or radioactive waste may have his/her permit placed on inactive status by notifying Radiation Safety Officer in writing. The permit may be reactivated following Radiation Safety Committee approval of a written request.

1.3.5 Special Authorization

Graduate students, post-doctoral researcher and non-tenure track faculty members will be authorized under special circumstances at the discretion and approval of the Radiation Safety Committee. These researchers may work under the direction of a Principal Investigator.

1.3.6 Termination of Authorization to Use

A Principal Investigator who plans to leave the University, or terminate his/her permit for any reason, must notify Radiation Safety Officer and arrange for the disposition of their radioactive materials by proper disposal or by transfer to another Principal Investigator.

1.4 THE RADIATION WORKER (AUTHORIZED USER (AU))

Radiation workers are those individuals trained to work with radioactive material, i.e. may be occupationally exposed, and work under the supervision of a Principal Investigator. The term Radiation Worker applies regardless of employment status (student, staff, faculty, etc.). These requirements also apply to PIs.

1.4.1 Responsibilities of the Radiation Worker

Individual radiation workers shall:

- a. Comply with all University radiation safety policies as described in this manual and any other radiation safety documents authorized by the Radiation Safety Committee, Radiation Safety Officer, or the Authorized User.
- b. Observe, understand, and obey radiological postings, signs, tags, and boundaries.
- c. Communicate honestly and effectively with the Advanced Radiation Worker, Authorized User, Radiation Safety staff, Radiation Safety Committee, and any State or Federal regulatory personnel regarding any radiological conditions, compliance issues, or concerns.
- d. Have the responsibility to maintain his or her own exposure to radiation and radioactive materials ALARA. This should include, but is not limited to:

- Being aware of the radiation hazards in their work area
- Properly handling and storing radioactive materials
- Using appropriate personal protective equipment
- Performing any required radiological monitoring

2 PRINCIPLES OF RADIATION SAFETY AND PROCEDURES

2.1 BASIC PRINCIPLES

It is the responsibility of any person involved in radiation procedures to minimize his or her own exposure” AS LOW AS REASONABLY ACHIEVABLE” (ALARA). The following principles will help personnel reduce their exposure.

- a. **TIME:** Since accumulated dose is directly proportional to time, the less time one spends around radiation, the less radiation exposure one receives.
- b. **DISTANCE:** The rate of radiation exposure decreased with increasing distance from the (point) source; thus, maintaining a large distance from a source of radiation offers a very practical avenue of protection.
- c. **SHIELDING:** offers a form of protection that requires prior planning and anticipation of safety requirements for a given situation. Protection offered by shielding depends on the following:
 - d. initial radiation dose rate without shielding
 - type and energy of the radiation
 - material used for shielding
 - thickness of the shield

Radioactive material and source can be categorized as external or internal hazards. External hazards are sources or materials which are not in direct contact with the body, but which may expose an individual to radiation. Protection from external sources is established by the use of shields and containers made of lead or other suitable materials, such as plastic shield for use of P-32; by use of distance as afforded by instruments with long handles, remote handling devices, etc.; and by reduction of time spent near radioactive materials through rapid and careful work.

Internal hazards are sources or radioactive materials, which may enter the body by one or more of the following four routes:

- ingestion with food or drinks, or with other material that comes into contact with the mouth
- inhalation of radioactive gases, vapors or dusts
- absorption through the skin or by means of a break in the skin
- accidental injection

2.2 RADIATION DOSE LIMITS

2.2.1 ALARA

It is the policy of University of North Texas that exposure to ionizing radiation will be As Low As Reasonably Achievable (ALARA).

2.2.2 Monitoring of External Radiation Exposure

Each radiation worker with the potential to exceed 10% of any annual exposure limit due to external radiation detectable by industry standard dosimetry will have that exposure monitored by the use of personnel dosimetry.

2.2.3 Radiation Exposure ALARA Action Levels

The radiation exposure ALARA Action Level 1 and 2, as described in Table 2.A, will apply to all radiation workers.

Table 2.A
Radiation Exposure ALARA Levels

Exposure Measurement	ALARA Action Level 1 mrem/calendar quarter	ALARA Action Level 2 mrem/calendar quarter
Total Effective Dose Equivalent (TEDE)	125	375
The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye	1875	5625
Shallow Dose Equivalent (SDE) to the skin or any Monitored Extremity (SDEME)	1875	5625
Lens of the eye Dose Equivalent (LDE)	750	2250

If any individual exceeds an ALARA action level, the Radiation Safety Officer will report the exposure to the appropriate Authorized User, Principal Investigator and the Radiation Safety Committee.

- a. PI with assistance from RSO, will be responsible for performing an investigation of the radiation exposure.
- b. A written summary of the investigation results, including potential corrective actions, should be provided to the Radiation Safety Committee.
- c. Persons who turn in two consecutive monitoring badges that are over the ALARA action level will be individually counseled by the RSO.
 - the person will be informed of the risk from radiation exposure
 - the reason for the exposure will be determined, if possible
 - changes in work habits, procedures, and equipment will be recommended as appropriate

2.2.4 *Internal Exposure Monitoring and Action Levels*

Radioactive Iodine Monitoring and Action Levels

Individuals should receive a thyroid bioassay after completion of operations involving, at one time, direct handling or use of unsealed radioiodine in individual quantities in excess of the quantities specified in Table 2.B.

**Table 2.B
Radioiodine Bioassay Requirements**

TYPE OF OPERATION OR PROCEDURE CONDUCTED	QUANTITY REQUIRING A BIOASSAY	
	volatile form*	BOUND TO NON-VOLATILE AGENT*
OPERATIONS PERFORMED IN AN OPEN ROOM OR BENCH.	>0.1 mci	>1 mci
OPERATIONS PERFORMED IN A FUME HOOD.	>1 mci	>10 mci

*Volatile forms include, but are not limited to, unlabeled sodium iodide (NaI) or operations involving acids or chlorine. Non-volatile forms are those that are chemically bound and used in such a manner that the radioiodine will remain nonvolatile and are diluted to concentrations less than 0.1 mCi/mg of non-volatile agent. Radioimmunoassay (RIA) kits are considered non-volatile.

Persons routinely working with individual quantities of radioiodine in excess of these amounts should have monthly bioassays. Scheduling of routine bioassays is the responsibility of the individual radiation worker.

The most favorable schedule for a thyroid bioassay is within 8 to 72 hours of exposure. The Radiation Safety officer will counsel persons with internal radioiodine exposures in excess of 10% of the applicable limit.

The Authorized User and Radiation Safety will evaluate the probable causes of the exposure and provide appropriate recommendation. The Radiation Safety Committee will be provided with written summary of the investigation results, including potential corrective actions.

Tritium Monitoring and Action Levels

- a. Individuals involved in operations, which utilize, at any one time, more than 100 mill curies of tritium in a non-contained form, other than metallic foil, shall have a bioassay performed within one week following a single operation, and at weekly intervals for continuing operations.
 - Tritium shall not be used in such a manner as to cause any individual to receive a radiation exposure such that urinary excretion rates exceed 28 microcuries of tritium per liter when averaged over a calendar quarter.
 - If the average concentration of tritium in urine for an individual during a calendar quarter is less than 10 microcuries per liter, urinalysis may be performed on that

individual at monthly intervals for the following calendar quarter and may continue at monthly intervals so long as the average concentration in a calendar quarter remains below 10 microcuries per liter.

- The urine specimen should be collected on the same day of the week, whenever practical.
 - Scheduling of routine bioassays is the responsibility of the individual radiation worker.
- b. A Radiation Safety Officer will counsel persons with more than 10% of the applicable limit for internal exposure of tritium.
 - c. The Principal Investigation and Radiation Safety Officer will evaluate the probable causes of the exposure and changes in procedures, work habits, or equipment will be recommended as appropriate.
 - d. A written summary of the investigation results, including potential corrective actions, should be provided to the Radiation Safety Committee.

2.2.5 Non-routine Bioassay Requirements

- a. If ingestion, inhalation, or absorption of any radioactive material is suspected, the RSO or designee will perform a bioassay or dose calculation.
- b. A Radiation Safety staff member will counsel any individual, whose internal exposure exceeds 10% of the applicable limit for the radioisotope, or sum of the radioisotopes.
- c. The Principal Investigator and Radiation Safety Officer will evaluate the probable causes of the exposure and changes in procedures, work habits or equipment will be recommended as appropriate.
- d. A written summary of the investigation results, including potential corrective actions, should be provided to the Radiation Safety Committee.

2.2.6 Airborne Radioactivity Exposure

Any intentional exposure of individuals to airborne radioactive materials or conduct of a project, which will require the use of radiological respiratory protective equipment, is highly restricted. Such actions will require the development of procedures, plans, and/or protocols for the proposed activity by the Principal Investigator and Radiation Safety Officer. A complete review and approval of the proposed project and associated documentation by the Radiation Safety Committee will be required prior to the initiation of any such activity.

2.3 PERSONNEL EXPOSURE LIMIT

2.3.1 Adults Occupational Exposure

The occupational dose to a radiation worker shall not exceed the following annual dose limits:

- A total effective dose equivalent (TEDE) of 5 rem; or,
- The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue, other than the lens of the eye, being equal to 50 rem.
- A dose equivalent of 15 rem to the lens of the eye.
- A shallow-dose equivalent of 50 rem to the skin or any extremity.

2.3.2 Minors Occupational Exposure

The annual dose limits for occupationally exposed minors (any individual less than 18 years of age) shall not exceed 10 percent of the annual dose limits specified above for adult workers.

2.3.3 Pregnant Women Occupational Exposure

Pregnancy declaration is voluntary under state and federal law. The dose limit for a pregnant radiation worker is 5,000mrem per year prior to a written and signed declaration. Upon declaration, the radiation safety officer will monitor exposure to the embryo/fetus. The dose equivalent to the embryo/fetus during the gestation period, due to the occupational exposure is 500mrem.

For instance, if the declared pregnant worker has received 450mrem or more in the period between conception and the declaration, the embryo/fetus is allowed an additional dose of 50mrem for the remainder of the pregnancy. Pregnancy declaration form

A pregnant radiation worker has the right to withdraw declaration at any time and without reason, including changes in work or pregnancy status. The standard occupational dose limits for a radiation worker will be reinstated upon withdrawal.

2.3.4 Exposure to Members of the Public

The total effective dose equivalent to individual members of the public due to licensed radioactive material or radiation producing devices will not exceed 100mrem in a year. This excludes dose contribution from background, medical treatments, or radioactive material disposed of via sanitary sewage performed in accordance with state and federal regulations.

3 FACILITIES AND EQUIPMENT CONSIDERATIONS

3.1 PURPOSE AND SCOPE

The purpose of this chapter is to describe the criteria for radiological use facilities and equipment in all areas controlled under the University's radioactive materials license. This chapter provides guidance to the Radiation Safety Committee, Radiation Safety Officer, and to prospective and Principal Investigator in evaluating the adequacy of radiological use facilities and equipment.

3.2 PRECAUTIONS

Proper facilities and equipment are an essential component of a good radiation safety program. Facilities and equipment that are inadequate or are improperly used or maintained may cause unsafe conditions with the potential to result in excessive personnel exposure or a loss of radiological controls.

3.3 LABORATORY CLASSIFICATION SCHEME

University of North Texas laboratory facilities shall be evaluated for suitability for use with unsealed radioactive materials in accordance with the guidelines of the following classification scheme. In the event that a deviation from this classification scheme is approved by the RSC, appropriate documented justification will be maintained. This classification scheme is referenced in *NUREG-1556, Vol. 11, Consolidated Guidance about Materials Licenses: Program-Specific Guidance about Licenses of Broad Scope*. Additional information about laboratory classifications is referenced from *The Health Physics and Radiological Health Handbook, Revised Edition, 1992*.

- a. Table 3.A describes the relative radiotoxicity of various radionuclides.
- b. Table 3.B describes the laboratory classification scheme.
 - Basic chemical laboratories are considered class C.
 - Class B is a specifically designed radioisotope laboratory. The class B designation includes a certified fume hood, appropriate radiological waste containers, dedicated radioactive material storage enclosures, and washing facilities suitable for decontamination use.
 - As described in Appendix K of NUREG 1556, "In the case of a conventional modern chemical laboratory with adequate ventilation and non-porous work surfaces, it may be possible to increase the upper limits of activity for type C laboratories toward the limits for type B for toxicity groups 3 and 4."
- c. The criteria describing the modifying factors as listed in Table 3.C is also used in the consideration of appropriate facilities for radioisotope use. Modifying factors take into consideration the type of operations performed or planned.

Table 3.A**Radiotoxicity Table of Representative Radioisotopes**

Radiotoxicity Group	Radioisotopes
Very High (group 1)	Pb-210, Po-210, Ra-223, Ra-226, Ra-228, Ac-227, Th-227, Th-228, Th-230, Pa-231, U-230, U-232, U-233, U-234, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Am-243, Cm-242, Cm-243, Cm-244, Cm-245, Cm-246, Cf-249, Cf-250, Cf-252
High (group 2)	Na-22, Cl-36, Ca-45, Sc-46, Mn-54, Co-56, Co-60, Sr-89, Sr-90, Y-91, Zr-95, Ru-106, Ag-110m, Cd-115m, In-114m, Sb-124, Sb-125, Te-127m, Te-129m, I-124, I-125, I-126, I-131, Cs-134, Cs-137, Ba-140, Ce-144, Eu-152, Eu-154, Tb-160, Tm-170, Hf-181, Ta-182, Ir-192, Tl-204, Bi-207, Bi-210, At-211, Pb-212, Ra-224, Ac-228, Pa-230, Th-234, U-236, Bk-249
Moderate (group 3)	Be-7, C-14, F-18, Na-24, Cl-38, Si-31, P-32, P-33, S-35, Ar-41, K-42, K-43, Ca-47, Sc-47, Sc-48, V-48, Cr-51, Mn-52, Mn-56, Fe-52, Fe-55, Fe-59, Co-57, Co-58, Ni-63, Ni-65, Cu-64, Zn-65, Zn-69m, Ga-72, As-73, As-74, As-76, As-77, Se-75, Br-82, Kr-85m, Kr-87, Rb-86, Sr-85, Sr-91, Y-90, Y-92, Y-93, Zr-97, Nb-93m, Nb-95, Mo-99, Tc-96, Tc-97m, Tc-97, Tc-99, Ru-97, Ru-103, Ru-105, Rh-105, Pd-103, Pd-109, Ag-105, Ag-111, Cd-109, Cd-115, In-115m, Sn-113, Sn-125, Sb-122, Te-125m, Te-127, Te-129, Te-131m, Te-132, I-130, I-132, I-133, I-134, I-135, Xe-135, Cs-131, Cs-136, Ba-131, La-140, Ce-141, Ce-143, Pr-142, Pr-143, Nd-147, Nd-149, Pm-147, Pm-149, Sm-151, Sm-153, Eu-152, Eu-155, Gd-153, Gd-159, Dy-165, Dy-166, Ho-166, Er-169, Er-171 (9.2 hr), Tm-171, Yb-175, Lu-177, W-181, W-185, W-187, Re-183, Re-186, Re-188, Os-185, Os-191, Os-193, Ir-190, Ir-194, Pt-191, Pt-193, Pt-197, Au-196, Au-198, Au-199, Hg-197, Hg-197m, Hg-203, Tl-200, Tl-201, Tl-202, Pb-203, Bi-206, Bi-212, Rn-220, Rn-222, Th-231, Pa-233, Np-239
Low (group 4)	H-3, O-15, Ar-37, Co-58m, Ni-59, Zn-69, Ge-71, Kr-85, Sr-85m, Rb-87, Y-91m, Zr-93, Nb-97, Tc-96m, Tc-99m, Rh-103m, In-113m, I-129, Xe-131m, Xe-133, Cs-134m, Cs-135, Sm-147, Re-187, Os-191m, Pt-193m, Pt-197m, Th-232, Th-Nat, U-235, U-238, U-Nat

Table 3.B**Laboratory Classification Scheme**

Radiotoxicity Group	Class C Laboratory Quantity	Class B Laboratory Quantity	Class A Laboratory Quantity
Very High	< 10 μ Ci	10 μ Ci to 10 mCi	10 μ Ci or more
High	< 100 μ Ci	100 μ Ci to 100 mCi	100 μ Ci or more
Moderate	< 1 mCi	1 mCi to 1 Ci	1Ci or more
Low	< 10 mCi	10 mCi to 10 Ci	10Ci or more

Table 3.C
Modifying Factors

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

3.4 FUME HOOD CRITERIA

Chemical type fume hoods provide a working area with a controlled inward airflow from the room to the hood exhaust system. Hoods should be used for gases, for unsealed volatile radioisotopes, and for processes such as evaporation that may release gases and vapors. Fume hoods provide emergency ventilation and exhaust for accidental spills, as well as routine exhaust of effluents. The criteria for radiological use of fume hoods is provided below.

- a. Up to 1 millicurie of non-volatile*, non-dust generating, not highly toxic radioisotopes may be used without a fume hood, if the materials and protocols are deemed acceptable by the RSC.
- b. Up to 10 millicuries may be approved for use in a standard fume hood, if the materials and protocols are deemed acceptable by the RSC.
- c. Up to 50 millicuries may be approved for use in a radioisotope fume hood with stainless steel lining and HEPA filtration, if the materials and protocols are deemed acceptable by the RSC.
- d. ***Note:** Volatile radioisotopes include, but are not limited to, the following: H-3 as tritiated water, NaBH₄, or acetic anhydride; C-14 as carbon dioxide gas; S-35 as cysteine or methionine compounds, I-125 or I-131 as unlabeled NaI or if combined with chlorine or in an acidic solution.

3.5 PORTABLE SURVEY INSTRUMENT REQUIREMENTS

- a. A radiological use laboratory must have a portable survey instrument suitable for detecting the radiation produced by the radioactive materials to be used. A borrowed instrument is only acceptable as a backup.
- b. This requirement does not apply to laboratories using exclusively H-3 or in other limited use situations that may be approved by Radiation Safety on a case-by-case basis.
- c. A suitable instrument typically has a thin window detector, calibration adjustment mechanism, and a display in units of millirem per hour. Instruments that display results exclusively in counts per minute are suitable for contamination (not radiation) monitoring only.

- d. Instruments must be calibrated on an annual basis. Calibration of portable radiation monitoring instruments is provided by the Radiation Safety Office.

3.6 COUNTING INSTRUMENTATION REQUIREMENTS

- a. A counting instrument suitable for determining the quantity of radioactive material present in a given sample media must be available to all Authorized Users of unsealed radioactive materials.
- b. A shared counter is considered appropriate, but the room where the counter is located should be listed on each user's radioactive materials permit, unless otherwise approved by the RSO.
- c. A liquid scintillation counter is recommended for use with isotopes that primarily emit beta radiation.
- d. Other counters such as gas proportional counters, gamma well counters, etc. may be more suitable for counting specific isotopes, such as low energy gamma emitters.
- e. Counting instruments should only be used in accordance with the manufacturers design criteria.
- f. Instrument performance checks including the measurement of radioactive standards should be conducted at a frequency adequate to ensure proper operation of counting instrumentation.

3.7 RADIATION SHIELDING AND DOSE RATE EVALUATIONS

- a. Radiation shielding in the form of bricks, panels, storage containers, and other shapes should be used when appropriate to keep exposure rates ALARA.
- b. Plexiglas, Lucite, or other high-density plastic shielding is recommended when using milliCi quantities of P-32.
- c. Lead shielding is recommended for use with milliCi quantities of I-125 and I-131, or with other gamma emitting isotopes with potential exposure rates of >1 mrem/hr @ 1 foot.
- d. Shielded shipping containers should be used for storage of radioactive materials after receipt, unless other containers having equivalent or better shielding is used.
- e. Radioactive materials that have the potential to generate significant dose rates, especially in the form of sealed source irradiators, should be evaluated by dose rate calculations in addition to any vendor supplied data. Formulas for use in dose rate calculations are available in Chapter 10, Laboratory Procedures.
- f. Upon initial setup of a sealed source irradiation device that has the potential to generate a dose rate in excess of 5 mrem/hr. @ 30 cm(12 inches), surveys by the Radiation Safety Office should be used to establish operational parameters and verify dose rates for restricted and unrestricted areas.

3.8 GENERAL CONSIDERATIONS

- a. Bench top or open work areas may be used for handling small quantities of solid materials in a form not likely to become airborne or dispersed, and for small quantities of liquids of such low volatility as not to cause airborne contamination or toxicity problems.
- b. Trays and/or absorbent surface covers (secondary containment) to catch and retain spilled liquids should be used in all appropriate radioisotope work locations.
- c. Radioactive materials that are handled or used in unsealed forms should be confined to control the release of materials and to prevent the spread of contamination. Gaseous, volatile, and fine particulate solid materials should be handled in fume hoods as described in section 3.0 of this procedure.
- d. Radioisotopes sewer disposal sinks must be properly monitored and maintained. Prior to maintenance or repair of discharge plumbing, the piping should be flushed with water and surveyed for the presence of radioactivity.
- e. Containers for radioactive waste should be labeled and placed near waste-generating areas and away from frequently occupied areas, when applied. Secondary containments should be used for liquid waste containers. Waste containers should be shielded as needed to keep dose rates ALARA.
- f. Radioactive materials security devices must be adequate to prevent unauthorized access and should be commensurate with the relative hazard of the radioisotopes involved (i.e. large quantity sources may require additional security).
- g. A physical barrier is required between radioactive material areas and areas used for eating, drinking, food storage, etc. There should be walls and doors separating these areas.
- h. Proper lighting, good housekeeping, and appropriate laboratory safety equipment must be maintained.

4 RADIOISOTOPE LABORATORY SETUP GUIDE

4.1 PURPOSE AND SCOPE

The purpose of this chapter is to assist the Authorized User (AU) in properly setting up a laboratory for the use of unsealed radioactive materials. This guide is intended to be used in the initial setup of a laboratory and is also a useful reference for existing facilities or for persons relocating their laboratories.

4.2 PRECAUTIONS AND LIMITATIONS

Prospective users should plan their setup procedures but may not want to begin procurement of materials (i.e. waste containers) until they have been notified that their radioactive materials use has been approved by the Radiation Safety Committee. Prior to setting up a laboratory for radioisotope use ensure that all general lab safety equipment is in place and suitable for use. The lab safety representatives of the Environmental Health Safety Services should be consulted for specific requirements. Some recommendations of this guide are mandated by regulatory requirements established by state or federal agencies and are described in the UNT Radiation Safety Manual. The information in this guide should be used as a supplement and not a replacement to those regulations and documents.

4.3 INSTRUCTIONS FOR THE USE OF THIS GUIDE

This guide is provided primarily as a tool for your use. For new Principal Investigators, access to procurement of radioactive materials will not be granted until the required laboratory setup has been verified as complete by the Radiation Safety Officer or designee.

Contact Information for the UNT Radiation Safety Staff

Primary Responsibilities, E-mail Address, Telephone Number

Director
Environmental Risk
940-565-2167

Radiation Safety Officer
RSO@UNT.edu
940-565-4196

Assistant RSO
RSO@UNT.edu
940-565-2123

4.4 PLANNING

- a. Plan your radiological work in relation to the layout of the laboratory.
- b. Consider the locations of storage freezers, fume hoods, workbenches, sinks, counting equipment, waste receptacles, etc. When practical, it is better to keep your radiological use components in close proximity to each other to reduce the likelihood of spreading contamination. The exception to this is to allow an appropriate distance between personnel and sources of radiation likely to result in personnel exposure. If you want to relocate any large equipment, it is generally easier to do so before you begin radiological work than after.
- c. A physical barrier is required between radioactive material areas and areas used for eating, drinking, food storage, etc. There should be walls and doors separating these areas.
- d. Look under sinks for evidence of water leaks; it is better to have them fixed now than to find leaks after you begin use of radioisotopes.
- e. Verify that laboratory equipment planned for use with radioactive materials is properly functioning (centrifuge, freezers, incubators, etc.) prior to radiological use.
- f. A radiation survey should be performed in the laboratory prior to the start of radioisotope use. To perform this task, slowly walk through the laboratory taking radiation readings with a portable survey instrument and record the results.
- g. These readings indicate the background radiation levels for your location. The average background levels should be about $<0.02\text{mr/hr}$. Levels in excess of 0.05mr/hr . should be investigated.

4.5 RADIOACTIVE MATERIALS SECURITY

Federal and state regulations require that radioactive material to be secured from unauthorized use. UNT requires radioactive materials laboratories to be locked, or that radioactive materials within laboratories be kept in locked enclosures or that trained individual continuously occupy the lab and are willing to prevent unauthorized access. As a part of laboratory setup, you should:

- ensure that locks are properly working and access is available for appropriate Radiation Workers
- provide locking devices on storage cabinets, freezers, waste containers, and the like as needed to control access

4.6 PROTECTIVE COVERINGS AND SECONDARY CONTAINMENT

- a. Areas with the potential for becoming contaminated should be evaluated before applying protective coverings. The first step is to ensure, whenever probable, that underlying surfaces are made of non-porous materials.
- b. Consider the use of trays or bins, which can catch small spills and are easily decontaminated.

- c. Remember that radioisotope work areas are not the only sources of contamination. Consider where you will store lab equipment used with radioisotopes, such as glassware and other small items. If these items are stored in drawers or cabinets, use removable trays or coverings to protect underlying surfaces from contamination.
- d. Apply protective coverings, which have an absorbent work surface and waterproof backing when appropriate. However, excessive use of such materials can contribute to unnecessary generation of radioactive waste.
- e. Use secondary containment devices for any bulk storage of liquid radioisotopes. This should include the use of trays or bins under your liquid waste carboys to contain spills or leakage.

4.7 FUME HOODS

- a. The use of an approved fume hood is required for any activity likely to generate dust, fumes, or vapors containing radioactive materials.
- b. Fume hoods should be used when working with volatile radioactive materials, and when initially opening vials containing millicuries quantities of radioisotopes.
- c. The Risk Management Services should certify fume hoods on an annual basis. If your fume hood does not have a current certification label, contact RMS to have it checked.

4.8 SPILL KITS

- a. All radioisotope use locations should have a spill kit appropriate for the intended use, such as the “Attack Pak” brand name spill kit.
- b. Spill kit locations should be easily accessible and not blocked by other items.
- c. When training laboratory workers, remember to inform them of the locations of spill kits and how to use the equipment.
- d. Spill kits can also be prepared from readily available supplies. A spill kit should include absorbent materials (vermiculite, “kitty litter”, sorbent pillows or pads), PPE (gloves), and items to be used in cleanup of the absorbent material (bags, a dustpan or scoop, etc.).

4.9 PERSONAL PROTECTIVE EQUIPMENT (PPE)

- a. Lab coats and disposable gloves should be procured and available for use. This is considered the minimum acceptable PPE for handling unsealed radioactive materials.
- b. Eye protection in the form of safety glasses or goggles should be available for use by persons handling unshielded or millicuries quantities of P-32, or when performing operations with the potential for liquid splash.

4.10 RADIATION SHIELDING

- a. Plexiglas or Lucite shielding is recommended for laboratories using milliCi quantities of P-32. Self-supporting shields and blocks designed to hold glassware are commercially available from lab safety supply companies.

- b. Lead shielding is recommended for use with milliCi quantities of I-125/131, or with other gamma emitting isotopes with potential exposure rates of >1 mrem/hr @ 1 foot.
- c. Spare shielding materials are sometimes available from Radiation Safety; call for details.

4.11 PORTABLE SURVEY INSTRUMENTS

- a. A radiological use laboratory must have a portable survey instrument suitable for the radioactive materials planned to be used. A borrowed instrument is only acceptable as a backup.
- b. This requirement does not apply to laboratories using exclusively H-3. The exclusive use of I-125 immunoassay kits with <10 microCi per kit is also exempted.
- c. A suitable instrument typically has a thin window detector, a calibration adjustment mechanism, and a readout in units of millirem. One recommended example of a general purpose instrument suitable for radioisotope laboratory use is the Ludlum Model 3 with 44-9 probe. Information on the Ludlum brand of monitoring instruments is available on their website at Ludlums products
- d. Instruments must be calibrated on an annual basis. Calibration of portable radiation monitoring instruments is a service provided by the Radiation Safety Office.

4.12 COUNTING INSTRUMENTATION

- a. A liquid scintillation counter is the standard instrument recommended for counting of wipe tests and for liquid analysis for sewer disposal.
- b. A shared LSC is considered appropriate, but the room where the LSC is located must be listed on your permit.
- c. Biodegradable scintillation fluids must be used in order to avoid the generation of mixed radioactive waste. One recommended biodegradable scintillation fluid for general purpose counting is Ecoscint from National Diagnostics. The Fisher products Cytoscint and Scintisafe are also good biodegradable LSC fluids.
- d. Other counters such as gas proportional counters, gamma well counters, etc. may be suitable for wipe test counting and analysis of liquid samples for sewer discharge. If you need additional information about a particular instrument, refer to the manufacturer's technical manual or contact the Radiation Safety Office.

4.13 PERSONNEL DOSIMETRY

- a. Dosimetry is required for all individuals working with gamma and high energy beta emitting isotopes (P-32, I-125, I-131, Na-22, Tc-99m, Cr-51, etc.) except as noted below.
- b. Radiation Workers without dosimetry may perform limited tasks approved and supervised by the PI. Individuals without dosimetry shall not be exposed to dose rates >2mR/hr. and should not be allowed to frequent areas with dose rates > 0.2mR/hr. These radiation exposure levels are for whole body dose rates as measured at 30 cm (approximately 1 foot) from the radiation source.

- c. Extremity monitoring (finger rings) is required for all individuals performing operations that involve direct handling of un-shielded containers of individual quantities of >1millicurie of P-32 or other gamma and high-energy beta emitting isotopes.
- d. Dosimetry is not required for personnel working in laboratories permitted only for milliCi quantities of isotopes, which emit primarily beta radiation with energies below 250keV (H-3, C-14, S-35, and P-33). The exclusive use of I-125 immunoassay kits with < 10microCi per kit is also exempted.
- e. Individuals required to have dosimetry must make a request for a dosimetry badge from the Radiation Safety Office. Dosimetry is a service provided by Risk Management Services.
- f. Dosimetry may be discontinued for individual workers on a case by case basis if historical data indicates that exposures are consistently minimal. This determination will be made by the radiation safety staff. In most cases a representative individual in the laboratory who performs the majority of the radiological work will continue to be monitored with dosimetry.

4.14 RADIOACTIVE WASTE CONTAINERS FOR DRY MATERIALS

The currently approved container for dry, solid radioactive waste is a 30 gallon fiber drum with lid.

Alternative containers that may be used include 5 gallon plastic pails with secure screw top lids and 10 to 20 gallon capacity all fiber drums. The all fiber drums are recommended for incinerable H-3/C-14 dry waste. Plastic pails are appropriate for small quantity generators and provide additional shielding for high energy beta emitters such as P-32.

Separate containers must be provided for each of the following materials:

- Short lived radioactive materials (half-life < 120 days)
 - Long lived radioactive materials (half-life > 120 days)
 - Mixed radioactive waste (contact the Radiation Safety staff for details)
- Ensure that each waste container has a “Caution, Radioactive Materials” labels on it prior to use. Radiation Safety Office can provide these labels and a minimum of 2 labels should be put on opposite sides of the container.
 - The form “Solid Radioactive Waste Log” should be used to document the contents of each waste container.
 - Users of P-32, radioiodine, and other gamma emitters should consider the need for shielding waste drums. Commercially made shield boxes are available through lab safety suppliers.
 - The PI to allow for the anticipated volume of waste generated should procure a sufficient quantity of radioactive waste containers and liner bags (> 6 mil thickness). After decay in storage for 10 half-lives, short-lived waste containers will be returned to the PI.

4.15 RADIOACTIVE WASTE CONTAINERS FOR LIQUID WASTE

- a. The currently approved container for liquid radioactive waste is a 2.5-gallon polycarboy.
- b. Separate containers must be provided for each of the following materials:
- c. Short lived radioactive materials (half-life < 120 days)
- d. Long lived radioactive materials (half-life > 120 days)
- e. Mixed radioactive waste (contact Radiation Safety for details)
- f. Ensure that each waste container has a “Caution, Radioactive Materials” label on it prior to use. Radiation Safety Office can provide these labels and a minimum of 2 labels should be put on opposite sides of the container.
- g. The form “Liquid Radioactive Waste Log” should be used to determine the activity of each waste container prior to pick up.
- h. Other forms may be used for analysis of low-level liquids for release or for sewer disposal. See the Radiation Safety Manual for details or contact the Radiation Safety staff for assistance.
- i. Liquid waste carboys should be stored in trays or bins, which provide secondary containment for preventing spills.
- j. The PI to allow for the anticipated volume of waste generated should procure a sufficient quantity of liquid radioactive waste containers. After decay in storage and/or sewer disposal by Radiation Safety, liquid waste containers will be returned to the PI.

4.16 RADIOACTIVE MATERIAL SIGNS AND LABELS

- a. Doors to radioactive material areas must be posted with a radioactive materials sticker on the standard laboratory hazard door sign. In addition the posting “Notice to Employees” is required. The Radiation Safety staff will provide these postings. Other labeling materials should be procured by the PI and are generally available through commercial lab safety suppliers.
- b. All enclosed containers, freezers, refrigerators, equipment, or cabinets where radioactive materials or contaminated items are used or stored must be labeled with the standard radiation symbol and the words “Caution, Radioactive Material.”
- c. Radioactive waste containers must be labeled as previously discussed.
- d. Tape bearing the standard radiation symbol and the words “Caution, Radioactive Material” should be used to post the boundaries of all countertops and similar locations routinely used for radioisotope work.
- e. Containers of radioisotopes should be marked with the standard radioactive material markings and should additionally be labeled with the isotope, quantity (mCi or microCi), and date.

- f. Instruments that contain radioactive sources such as GC's and LSC's should be labeled with a "Caution, this instrument contains radioactive material" sign or approved equivalent. These instrument labels are available from Radiation Safety.

4.17 RADIATION SAFETY TRAINING

- a. Any individual that wants to use radioisotopes must receive training by the Radiation Safety Officer.
- b. Initial radiation safety training should be completed before the use of radioactive material.
- c. An annual refresher training is required.

4.18 RADIATION SAFETY RECORDS

Records in support of the requirements described in the Radiation Safety Manual must be maintained in the laboratory. Blank copies are available by contacting the Radiation Safety Office. The following records must be maintained in the radiation safety binder.

- a. Emergency Telephone numbers
- b. Radioactive materials permit and amendments
- c. Radiation Emergency Procedures
- d. Package receipt and Daily use log
- e. Radiological Wipe Form
- f. Radiological Survey Form
- g. Solid Radioactive Waste Log
- h. Liquid Radioactive Waste Log
- i. Quarterly Inventory

5 PROCUREMENT AND TRANSFER OF RADIOACTIVE MATERIALS

5.1 PROCUREMENT POLICY

The University policy is that all orders for radioactive materials must be placed according to Procurement guidelines. Direct purchases from suppliers are prohibited, regardless of the amount to be expended. Radioisotope deliveries will be made to Radiation Safety Office, unless the Radiation Safety Committee grants a written exception.

5.2 PRECAUTIONS / PREREQUISITES

- a. Prior to ordering radioactive materials, Principal Investigator must be approved by the RSC for the type and quantity of radioactive materials desired.
- b. Individuals performing transportation, shipment, or receipt of radioactive materials must have training in the requirements of this procedure and in the proper performance of radiological surveys.
- c. Personnel opening radioactive material packages or working with radioactive materials shall wear personnel protective equipment (PPE) and dosimetry as required by this manual.

5.3 ORDERING PROCEDURE

The Radiation Safety Officer is responsible for assuring that the types; forms and quantities of radioactive materials possessed at any one time do not exceed those authorized on the radioactive material license. The RSI is also responsible to ensure that the radioactive materials will be used following an approved procedure and under the supervision of a responsible user.

The RSO discharges these responsibilities, in part, by the review and the approval or denial of requests to purchase radioactive materials. All purchase orders for radioactive materials are routed through the Radiation Safety Office for approval.

The RSO reviews each purchase order to determine if:

- If the University is licensed for the type of radioactive material requested.
- The form of radioactive material is acceptable under the license.
- The activity, when added to the inventory already on campus, will not exceed licensed possession limits.
- The Principal Investigator is permitted to use the isotope and approved for the quantity been requested.

Purchase Order (PO)

The Principal Investigator or designee initiates a purchase order for a radioisotope in accordance with the University's procurement guidelines. The purchase order should clearly indicate:

- Radioisotope, (H-3, C-14, etc.);
- Total activity, (μCi or mCi);
- Chemical and physical form, (e.g., as polyphosphate in aqueous solution);
- Licensed user under whose supervision it will be used. Failure to provide the needed information may cause delay in the approval and purchase of the radioisotope

Routing the PO

The purchase order should be routed through the Radiation Safety Office for review.

Radiation Safety Office Review

The RSO determines if:

- The radioisotope requested is permitted under the University's Radioactive Materials License;
- When added to existing inventory, the requested activity won't exceed allowable licensed inventory for that radioisotope;
- The radioisotope will be used by a licensed user or under a licensed user's direct supervision; and
- An existing, approved protocol covers the intended use.

Approval

The RSO will approve the purchase order if it is acceptable under the radioactive materials license. If a purchase order is unacceptable, it will not be approved.

Records

The Radiation Safety Office retains approved purchase orders.

5.4 RECEIPT AND INVENTORY TRACKING OF RADIOACTIVE MATERIALS

Radiation Safety Office will receive and process all shipments of radioactive materials and will re-deliver the shipments to the final delivery point designated on the purchase request form. Central Receiving will not be involved with such deliveries. The Principal Investigator or their designee will be responsible for routine the shipment to Radiation Safety Office.

Note: Radiological surveys of the exterior surfaces of radioactive material shipments shall be performed as soon as practicable after receipt of the package, but not later than three hours after the package is received if receipt occurs during normal working hours. Packages that are not received during normal working hours are required to be surveyed within three hours of the next normal workday following receipt.

5.4.1 *Inspection and Redelivery*

- For deliveries directed to Radiation Safety Office, radiation staffs will perform a receipt inspection of each package and evaluate compliance with the requirements of this procedure. If no discrepancies are noted, the Radiation Safety staff will make re-delivery to the Principal Investigator or their designee, usually on the same day. A Package receipt and Daily use log will be prepared and delivered with each shipment. The Package

receipt and Daily use log must be maintained on file after the radioactive material has been used-up and disposed.

- b. Any shipment of radioactive material with more than 1000 dpm/100cm² of removable contamination on either the outside package or the inside container will not be delivered to the Principal Investigator or their designee. The vendor should be contacted and arrangements made for a replacement shipment. The shipment may be returned to the vendor or disposed of as waste. The Principal Investigator will be notified that the shipment has arrived, that it is contaminated and that a replacement should be ordered. Vendor notification for replacement shipments is the responsibility of the Principal Investigator. The Procurement should be made aware of this notification.
- c. In the case of a PI approved for direct delivery, an individual trained in the requirements of this procedure will be responsible for performing the receipt inspection. The individual performing the receipt inspection must complete a Package receipt and Daily use log documenting the shipment receipt and radiological survey data. A copy of the log must be forwarded to Radiation Safety Office.

5.4.2 *Receipt Inspection Procedure*

- a. Individuals performing receipt inspections of radioactive materials must have complete "Preparation and Shipment of Radioactive Material in accordance with state and Federal requirements for the transportation of radioactive hazardous material.
- b. Personnel opening radioactive material packages shall wear a minimum PPE of gloves to prevent hand contamination.
- c. Wear personnel dosimetry in accordance with the requirements of this manual when working with radioactive materials.
- d. Visually inspect the package for any signs of damage, including crushed or punctured containers or signs of leakage. If any signs of damage are noted, store the package within a secondary containment and notify the RSO. Also if possible, request that the person responsible for delivery of the package remain in the area until they can be monitored for contamination. If removable contamination on the outside of the package is confirmed to be in excess of the limits specified below, notify the RSO.
- e. Check the packing slip for a description of the contents and verify that the isotope and activity of the shipment does not exceed license (or permit) limits.
- f. Survey the exterior of the package for radiation dose rates. Measure and record the maximum reading at contact on the package and the reading at 1 meter from the package. Compare the results to Table 5 of this chapter. If the dose rate values do not comply with the labeling of the package, notify the RSO or designee. Do not proceed with opening the package.
- g. Survey the exterior of the package for transferable contamination by performing a wipe test of an area of approximately 300 cm². Count the wipe in an appropriate counting instrument. Results should not exceed 200 dpm/100cm² and shall not exceed 1000

dpm/100cm². If results exceed 1000 dpm/100cm² notify the RSO or designee. Do not proceed with opening the package.

- h. If no external contamination is indicated, open the package and carefully remove the packing material until the final source container is reached. Again, check for any obvious signs of leakage and take appropriate precautions.
- i. Packages that contain volatile radioactive materials (I-125, I-131, S-35, H-3, etc.) in quantities greater than limited quantity shipments should be opened in a fume hood, if available. When appropriate, use shielding to reduce personnel exposure.
- j. Perform a wipe test of the exterior of the inner-most radioactive materials container. Results shall not exceed 1000 dpm/100cm². If results exceed 1000 dpm/100cm² notify the RSO or designee. Do not proceed with use or delivery of the package unless approved by the RSO.
- k. Verify that the inner container labeling is correct with the packing slip. Again, this should be done to confirm that the isotope and activity of the shipment does not exceed license (or permit) limits.
- l. Re-package the inner container into the original shipping package for delivery to the final destination

Table 5.A
Shipping Label Requirement and Dose Rate Limits.

Label Category	Maximum External Contact Dose Rate	Transport Index (TI)*
Limited Quantity	≤0.5 mrem/hr.	0
White I**	≤0.5 mrem/hr.	0
Yellow II	>0.5 to 50 mrem/hr.	0 to 1
Yellow III	>50 to 200 mrem/hr.	1 to 10

Note:

*The TI is determined by the dose rate at 1 meter (3.3 feet) from the external surface of the package. TI values should be rounded up to the next tenth. The TI value is considered to be zero if the 1 meter dose rate is <0.05 mrem/hr.

**The White I category differs from the Limited Quantity category in that the Curie content exceeds the criteria for a limited quantity of material. Limited quantity values are shown in Table 6.A. of this procedure.

5.4.3 Inventory Record Keeping

The Principal Investigator has the responsibility to keep accurate and up-to-date records of all radioactive materials in their possession. Use Package receipt and Daily use log to maintain accurate use log of all radioactive materials. It is strongly recommended that copies of this form be kept in a dedicated location, preferably in the radiation safety binder, for easy access and organization. The University's radioactive materials license requires the performance of a

physical verification of radioactive material inventory every quarter. This record should be sent to the Radiation Safety Officer.

5.4.4 Receipt of Devices Possessed Under a General License

Individuals who are already in possession of items received under a general license must inform Radiation Safety Office of the radioactive materials in their possession when they begin working at the University. Individuals planning to acquire these items should contact Radiation Safety Office to arrange a transfer. These items must be tracked and controlled in accordance with the University's radioactive materials license. Some examples of items typically controlled under a general license include the Nickel-63 sources in electron capture detectors as found in certain gas chromatographs and the calibration sources in some liquid scintillation counters.

Gas chromatographs and similar measuring/ gauging devices that contain sealed radioactive sources may be procured and used by personnel other than Principal Investigators if appropriate controls are met. Procurement, transfer, monitoring, training, and registration for these devices must be coordinated with Radiation Safety Office.

5.5 TRANSFER OF RADIOACTIVE MATERIALS

5.5.1 External Transfers

Licensed radioactive materials shall not be transferred from one institution to another without the approval of the RSO. The RSO of the institution desiring to make the transfer must contact the RSO of the receiving institution prior to making the transfer. Any individual wishing to initiate or receive an external transfer must notify the RSO well in advance of the transfer. Principal Investigator and their designee must comply with the requirements for labeling, shipping, and receiving of radioactive materials as described in this manual and 49 CFR 173.

5.5.2 Internal Transfers

Radioactive materials may be transferred from one Principal Investigator to another by the internal transfer process. These transfers must be coordinated through the Radiation Safety Office and approved before the transfer takes place. The inventory records for both PI's will have to be updated by the Radiation Safety staff. The PI receiving the radioactive materials must be approved for the quantity and type of materials to be transferred and the transfer must not cause their possession limits to be exceeded.

The Radioactive Material Permit form must be completed and signed by both PI's involved in the transfer. In addition, must comply with the requirements of section 5.0 of this procedure.

5.5.3 Gifts and Donations

Gifts and donations of radioactive materials must be controlled in the same manner as for internal and external transfers.

5.5.4 *General Transfer Requirements*

- a. Radioactive materials may only be transferred from a Principal Investigator's approved location or from a PI to another after receiving approval from Radiation Safety Office.
- b. A University researcher who requests to use radioactive materials at any location must contact Radiation Safety office in advance of the proposed use.
 - If the proposed site is a University's licensed location, a month notice should be sufficient.
 - If no license exists for use of radioactive materials at the desired site, then a license amendment must be obtained from the State of Texas Department of State Health Services. A minimum of one month and possibly longer may be required. If the site is out-of-state, requiring coordination with other state regulatory agencies, the required time may be even longer.

6 RADIOLOGICAL SURVEYS

6.1 PURPOSE AND SCOPE

This chapter describes the methodology for performance of radiation and contamination surveys of areas where radioactive materials are used, stored, or suspected to be present. Specific survey requirements for radioactive materials shipments, leak rate testing of radioactive sources, and x-ray equipment are not described in this chapter.

The primary purpose of radiation surveys is to identify the magnitude (or verify the absence) of dose rates so that personnel exposure to radiation is maintained As Low As Reasonably Achievable (ALARA).

The primary purpose of contamination surveys is to identify the quantity (or verify the absence) of radioactive contamination on surfaces. The objective is to prevent the inhalation, ingestion, or absorption of radioactive contamination by personnel and to ensure that contamination is not spread to the surrounding environment.

The documented performance of radiological surveys is required by Title 10, Part 20 of the Code of Federal Regulations and by the State of Tennessee Rules and Regulations for Radioactive Materials.

6.2 PRECAUTIONS AND LIMITATIONS

Wear appropriate personnel protective equipment (i.e. lab coat & gloves) during the performance of activities with unsealed radioactive materials or the potential to encounter radioactive contamination.

Use the ALARA principles of time, distance, and shielding to reduce your exposure to radiation during the conduct of radiological surveys.

6.3 TERMS AND DEFINITIONS

- Radiological survey – an evaluation of radiological conditions by testing, measurement, or calculation.
- Contamination – radioactive material in an undesirable location, or transferable contamination in excess of the limits specified in Table 6.1 of this chapter.
- Radiation – energy in the form of particles or waves emitted from a radiation source.
- Direct scan survey – use of the direct scan technique to measure the activity emitted from a surface. The radiation detected is the total result of any fixed and transferable

contamination on the surface, and of any radiation that may be penetrating through the surface or emanating from another source.

- Transferable contamination survey – An assessment of the amount of readily removable contamination present on a surface. A collection medium is used to wipe a surface while applying moderate pressure. The amount of activity detected on the collection medium is then determined using radiological instrumentation.
- Wipe survey – the use of a collection medium (paper disc or equivalent) to cover approximately 100 square centimeters of surface area in the assessment of transferable contamination.
- Large area wipe survey – the use of a collection medium (paper towel, disposable wipe, or equivalent) to perform a transferable contamination survey of a surface area significantly larger than 100 square centimeters.
- cpm – counts per minute; the observed count rate determined from the use of a counting instrument.
- dpm – disintegrations per minute; the rate of emission of radioactive material as determined by correcting the counts per minute for background, efficiency, and geometry factors.
- Contact dose rate – the radiation dose rate at (or near) contact with the radiation source. This value may be used to determine the extremity dose rate.
- 30 cm dose rate – the radiation dose rate measured 30cm (approximately 1 foot) from the radiation source, this value may be used to determine the whole body dose rate, skin/lens of eye dose rate, and deep dose equivalent exposure rate.
- General area dose rate – the dose rate at approximately 1 meter from the radiation source, or the generally occupied area dose rate, as measured at approximately waist level by the survey technician.
- mrem/hr. – the unit of dose equivalent rate.
- Unrestricted area – an area or location that is not controlled for the purpose of limiting exposure to radiation or radioactive materials. Controls include physical boundaries and radiological postings, signs, and labels.
- Restricted area – an area or location that is controlled for the purpose of limiting exposure to radiation or radioactive materials. A posted Radioactive Materials Area is an example of a restricted area.

- ND - a notation used to describe the survey result when no detectable radiation or contamination above instrument background level was found.

6.4 MONITORING INSTRUMENTATION

6.4.1 *Portable Instrumentation*

Radiation Safety should be contacted for training in the use of monitoring instrumentation. Refer to the vendor provided instrument technical manual for specific operating information. The following general information is applicable to most types of portable radiation monitoring instrumentation used in UNT laboratories.

- a. Pre-operational checks:
 - Verify that the instrument has a current and up to date calibration label, (instrument calibration services are available from Radiation Safety).
 - Inspect the instrument for physical damage.
 - Check the batteries, for instruments equipped with a battery test function.
 - Verify that the instrument is operational by checking for detection of normal background radiation. This should be done in a low background area away from sources of radiation. If routinely performed in the same location, consistent, reproducible results are an indication of a properly performing instrument.
 - Instruments, which are not capable of detecting background levels should be response, tested with a radiation source of known quantity. Response check sources may be available from Radiation Safety for this purpose.
- b. Selection of audible and response settings on portable instruments is left up to the discretion of the surveyor, however, the following settings are recommended:
 - Audible on - Normally used.
 - Audible Off - Recommended when the instrument higher scales are used, and at the discretion of the survey technician.
 - Fast Response - Recommended when surveying with audible off, using the instrument high range scales, or for contamination surveys.
 - Slow response - Normally used for dose rate readings on the low scales.

6.4.2 *Wipe Test Counting Equipment*

The type of laboratory equipment selected for counting wipe test samples is dependent on the radioisotope(s) to be detected and equipment availability. Typical instruments include a counter/scaler, gamma counter, or a liquid scintillation counter (LSC).

- a. Refer to the vendor provided instrument technical manual for specific operating and counting information.
- b. Whenever practical utilize known radioactive standards to conduct functional tests and verify instrument efficiencies (instrument cpm/actual source dpm = counter efficiency).

- c. Determine the minimum detectable activity (MDA) for the counting instrument prior to counting samples where a minimum activity threshold value is required. MDA varies with changes in counter background and counting times. Lower background levels and longer counting times enable a lower MDA value to be reached. Calculate the MDA by use of the formula:

$$\text{MDA in dpm} = \frac{2.71 + 4.66 \sqrt{\text{bkg cpm} \times \text{count time}}}{(\text{efficiency}) (\text{count time})}$$

Equation 6.1 minimum detectable activity

Example: A 1-minute counting time, 50 cpm background (bkg.), and LSC efficiency for H-3 of 0.33 would give a MDA of 96 dpm. Therefore, it would be appropriate to count a wipe sample for 1 minute for H-3 at this background level because the most restrictive limit is 200 dpm.

- d. Run background samples to calculate net counts per minute (gross cpm – bkg. = net cpm).
- e. Use instrument efficiencies to convert net cpm to dpm (net cpm / instrument efficiency = dpm).
- f. A simpler way to convert net cpm to dpm is to use a correction factor (CF). A correction factor is determined by the following method: CF = 1/efficiency. When using a correction factor to convert cpm to dpm use the following formula: cpm x CF = dpm
- g. The standard efficiency to be used when counting wipe samples with a LSC is 33%, which provides a correction factor (CF) value of 3. When counting wipe samples in a LSC, simply multiply the net cpm value by 3 to convert the results to dpm.
- h. The standard efficiency is based on the lowest counting efficiency (highest CF) for the radioisotopes typically used at UNT. This provides a uniform standard and eliminates the need for spectral analysis of wipe samples when the probability of multiple unidentified isotopes exists.
- i. The standard efficiency is appropriate for use when counting wipes in commercially available scintillation fluid, or for counting exclusively P-32 wipes using water (Cerenkov counting). In Cerenkov counting, water is used instead of liquid scintillation fluid. The Cerenkov Effect occurs when visible light in the blue spectrum is produced when a beta particle travels through a transparent medium faster than the speed of light in that medium. Counting wipes in water with an LSC is only approved for P-32, wipes for no other isotopes may be counted by this method.
- j. Table below provides the net cpm value that will equal 200 dpm and 1000 dpm when using the standard efficiency of 33%.

Table 6.A
CPM to DPM Conversion Using the Standard LSC Wipe Counting Efficiency

LSC standard wipe counting efficiency	Correction Factor	Net cpm to equal 200 dpm	Net cpm to equal 1000 dpm
0.33	3	67 cpm	333 cpm

- k. The net cpm values provided in the table above may be used as a wipe test counting guideline in meeting the criteria of restricted and unrestricted areas for transferable contamination.
- l. When using a counter other than a LSC for analysis of wipe samples, you should use the actual efficiency for the instrument and isotope being surveyed for. An exception to this occurs if the efficiency exceeds 33%, in this case you should use the 33% value to ensure consistency in analysis of wipe samples.

6.5 DIRECT SCANNING FOR CONTAMINATION

Direct scans of material/equipment/surfaces are performed to identify the amount of contamination (fixed and transferable) present on an accessible surface. It is important to understand that direct scans may also identify the presence of radiation from another source, such as radiation penetrating through the surface of a container. Direct scan surveys may be used to provide an initial assessment of the amount of total surface contamination. The contamination detected by direct scans may be fixed (non-transferable) or transferable. Transferable contamination survey techniques are described later in this procedure.

- Direct scan surveys for contamination are not required to be performed and documented during a routine monthly survey.
- Direct scan surveys are required to be performed and documented when surveying an item or component for release to unrestricted use.
- Direct scan surveys are a primary tool for contamination monitoring during and after the performance of radioisotope work.

6.5.1 DIRECT SCAN TECHNIQUE

- a. A pancake type GM thin window detector is the recommended instrument to perform direct scan surveys. Even with thin window detectors, these portable instruments will not detect H-3 and have a low efficiency for detecting low energy beta/gamma emitters.
- b. Perform direct scan surveys in a low background area. If it is necessary to transport an item to a lower background location, take appropriate steps to prevent the possible spread of contamination (i.e. survey for transferable contamination first).

- c. When scanning for contamination, position the detector approximately ½ inch above the surface being surveyed; slowly scan the surface at an approximate rate of 1 to 2 inches per second. Observe closely for increases on the meter display or in the audible signal.
- d. If contamination is known to be present on the surface, the scan speed may be adjusted to an appropriate speed for locating the maximum contamination level, as desired.
- e. If activity is detected, then hold the probe stationary until the meter stabilizes to obtain a reading.
- f. Any activity equal to or greater than 2 times background is a positive indication of contamination. The ALARA action level of <2 times background not to exceed <0.05 mr/hr is the appropriate limit for unrestricted areas, or for items to be released for unrestricted use.
- g. If high levels of contamination are detected take appropriate precautions to control or prevent the spread of contamination. Notify the Authorized User and/or Radiation Safety for assistance.

6.6 TRANSFERABLE CONTAMINATION SURVEYS (WIPE TEST)

Transferable contamination surveys are performed by wiping a known surface area (typically 100 cm²) with a collection medium. The concentration of radioactivity on the collection medium is then analyzed. This is an important survey technique because transferable contamination can be spread from one location to another and is a potential inhalation, ingestion, or absorption hazard. In addition, transferable contamination measurements are required to be performed and documented to maintain compliance with state and federal regulations.

In addition to the standard wipe testing technique described in section 6.6.1., two optional techniques may be used for special applications as described in sections 6.6.2 and 6.6.3 If you do not fully understand the limitations of these optional survey techniques, contact Radiation Safety for assistance.

6.6.1 Survey Technique - 100 cm² Wipe Tests

- a. 100 cm² wipe tests may be performed using filter papers or commercially available wipes or smears with an approximate diameter of 1” as the collection medium.
- b. Wipe the collection medium over the surface of the area being surveyed using moderate pressure such that 100 cm² is wiped (typically a 16”-18” lazy S pattern).
- c. Analyze the wipes using counting equipment as described in your laboratory standard protocols and section 3.2 of this chapter.
- d. If using a LSC, add an appropriate amount of biodegradable scintillation fluid and count the sample for a minimum of 1 minute (see sections 3.2 and 5.2 for special counting considerations if analyzing exclusively for P-32)

- e. If using a gamma counter or counter scaler, follow the standard counting protocol for the instrument
- f. Subtract the background count rate (cpm) from the gross count rate (cpm) to obtain a result in net cpm. Multiply the net cpm by the conversion factor of 3 to convert the result to dpm/100 cm².
- g. Wipe test results should be documented in units of dpm/100 cm² in the space provided on the radiological survey form (RSF).
- h. If wipe test results are <200 dpm (<66 cpm), the counting media should be disposed of as “clean” waste. Biodegradable liquid scintillation fluid may be disposed of via sink drains, empty vials and non-contaminated wipes should be discarded in regular trash.
- i. Compare the wipe test results to Table 5.1 (below) and take appropriate actions.

Table 6.B
Transferable Contamination ALARA Action Levels

Description	Action Level for Transferable Contamination (beta-gamma*)
Unrestricted Area	200 dpm/100cm ² (<66 cpm/wipe)
Restricted Area	1000 dpm/100cm ² (<333 cpm/wipe)

*Alpha contamination surveys will not be required unless work is performed with unsealed isotopes that primarily or exclusively decay by emission of alpha radiation. If alpha contamination surveys are required, transferable contamination limits will comply with regulatory guidance.

Note: The ALARA goal is to maintain all normally occupied routinely accessible areas at the unrestricted area transferable contamination action level.

6.6.2 *Optional Survey Technique – Portable Instrument Counting of P-32 Wipes*

Transferable contamination surveys that are preformed exclusively to monitor for P-32 in restricted areas (Radioactive Material Areas) may use the following technique. This technique is suitable for meeting the restricted area limit of 1000 dpm/100 cm², but is not to be used to meet the unrestricted area limit of 200 dpm/100 cm². In other words this method of counting wipes may be used for monthly surveys and routine monitoring inside of Radioactive Material Areas, but may not be used for surveys for release of items or equipment to unrestricted use, or for out-going radioactive materials shipments.

- a. Collect wipes by using 1.5” diameter paper or cloth disc smears (commercially available).
- b. Using a pancake GM detector (Ludlum 44-9 probe or equivalent), hold the detector approximately 1/4 inch above the collection surface of the wipe for approximately 5 seconds.
- c. Perform this check in a low background area only (<0.05 mr/hr). The instrument must be on a scale suitable to read <0.05 mr/hr (the x 0.1 scale for a Ludlum Model 3). Use of the audible response is recommended.
- d. If no increase is noted (listen for audible response) in the count rate, the results are equivalent to <1000 dpm/100 cm². The results should be recorded as ND in the cpm space provided for wipe test results on the Radiological Survey Form.
- e. If activity is indicated by use of the portable instrument, or if a more accurate count is desired, count the wipe in a LSC. Deposit the wipe in a scintillation vial and add an appropriate volume of water to fill the vial. Count the vial in the LSC for a minimum of 1 minute (Cerenkov counting). Subtract the background count rate and use the correction factor of 3 to convert the net counting results from cpm to dpm.

6.6.3 *Optional Survey Technique - Large Area Wipes*

Large area wipes are useful for routine monitoring of work areas. Large area wipes are not required to be performed and documented during routine monthly surveys. However, for specific situations approved by the RSO, large area wipes may be substituted for 100cm² wipe testing on a limited basis.

Large area wipes are only to be used as a positive/negative test for the presence of contamination. Due to the potential to spread contamination when wiping a large area, the primary use for large area wipes is to verify that normally “clean” areas have not become contaminated. Since large area wipes are read with a portable survey instrument, they will not detect H-3 and may not be suitable for detecting small quantities (i.e. 200 dpm) of low energy beta/gamma emitters.

Perform large area wipes in accordance with the following instructions.

- a. Large area wipes can be performed using paper towels, disposable wipes, disc smears or equivalent as the collection medium. Floors may also be surveyed by the use of dust mops that utilize treated cloths. If disc smears are used for large area wipe testing, a minimum disc diameter of 1.5” is preferred for optimum collection and counting results.
- b. Wipe the collection medium over the surface using moderate pressure. You should wipe an area at least 500 cm², but not so large as to cause degradation of the collection medium. A recommended technique for large surfaces (desks, bench tops, etc) is to wipe in an “S” shaped pattern of approximately 6.5 feet in length. Use multiple wipes when checking large surfaces or different locations.
- c. Perform a direct scan of the surface of the collection medium using a portable survey instrument, as detailed in section 6.5.1 of this chapter.
- d. If contamination is detected, take appropriate measures to control the potential spread of the contamination. A 100 cm² wipe test must be performed in order to quantify results. Compare the results to Table 5.1 for appropriate actions.
- e. Large area wipe surveys are not required to be performed and documented as a part of your monthly radiological survey. However, large area wipes may be recorded on radiological surveys as a supplement to regular wipe testing. If large area wipes are performed and no contamination is detected, the results may be documented by identifying the items or locations surveyed and recording the results. “ND” may be used to indicate no detectable contamination. A large area wipe survey that indicates contamination should not be documented, but must be followed by a sufficient number of wipe test surveys to accurately determine the magnitude and extent of the contamination. Refer to the RSF and the instructions provided by Radiation Safety for additional information.

6.7 RADIATION SURVEYS

Radiation surveys are performed to measure the dose rates (radiation fields) produced by sources of radiation, or to confirm the absence of these dose rates. Unless specifically exempted, radiation dose rate measurements are required to be performed and documented to maintain compliance with state and federal regulations.

The performance of radiation dose rate surveys is not required in authorized use locations where the radioactive materials are limited exclusively to milliCi quantities of isotopes that emit primarily beta radiation with energies below 250 keV (H-3, C-14, S-35, and P-33). The exclusive use of I-125 immunoassay kits with <25 microCi per kit is also exempted.

Radiological surveys of all other authorized use locations must include radiation dose rate surveys. The minimum requirement is to measure the radiation levels at 30 cm (1 foot) from potential sources of radiation, including storage areas, waste containers, and isotope use locations. Even if no increase over the background reading is noted, the survey must be documented as proof of compliance with the regulations.

During the performance of radiation surveys, remember to keep personnel exposure ALARA. In the event that significant radiation levels are detected, control access and notify Radiation Safety.

6.7.1 *Radiation Survey Techniques*

- a. Survey the entire area concern, noting fluctuations in the meter or audible response. Investigate any increase to determine the magnitude and location of the highest reading.
- b. Obtain 30 cm dose rate readings by measuring the radiation level at 30 cm (1 foot) from the radiation source or any surface from which the radiation emanates. 30 cm radiation levels may be used to establish whole body and skin/lens of eye exposure rates. These readings are also used in establishing radiological postings of areas.
- c. General area dose rates should be measured at an approximate distance of 1 meter from the radiation source, or from any surface from which the radiation emanates. These dose rates are appropriate for estimating exposure to support personnel working in the vicinity of personnel whose exposure rates are determined by 30 cm dose rates.
- d. General area dose rates are also useful in determining exposure rates for walkways and routinely occupied areas. General area dose rates taken for this purpose should consist of dose rate measurements taken at approximately waist level in normally occupied areas. If dose rates above area background are revealed by this method, additional surveys should be performed to determine the source of the radiation.
- e. Contact dose rates shall be taken with the detector of the instrument at or near contact with the surface from which the radiation emanates. In addition to locating the source of radiation, contact dose rates provide useful information for estimating extremity exposure.

6.7.2 *Radiation Dose Rate ALARA Action Levels*

- a. The ALARA action levels for radiation dose rates are shown in Table 6.2. Distances are measured from the source of the radiation, or from any surface from which the radiation is penetrating.

**Table 6.2
Radiation Dose Rate ALARA Action Levels**

Location	Dose Rate Action Level	Type of Measurement (source to detector distance)
Unrestricted Area	<0.05 mrem/hr	30 cm (whole body dose rate)
Restricted Area	<2 mrem/hr	30 cm (whole body dose rate)

- b. If the dose rates exceed the criteria described in Table 6.2 take appropriate actions. Locate the radiation source and consider shielding or re-locating the radiation source to reduce the dose rates. Consult with a member of the Radiation Safety staff for additional assistance.
- c. Dose rates in certain locations or situations are allowed to exceed the ALARA action levels of Table 6.2 if appropriate radiological controls are implemented. For example, these action levels may be exceeded during the conduct of procedures performed for a limited duration under the continuous control of trained Radiation Workers who ensure that no untrained personnel (members of the public) are exposed to radiation hazards. Contact Radiation Safety for evaluation of a specific situation.
- d. Radiation dose rates due to radioactive material shipments that are appropriately packaged, labeled, and are in transport are exempt from the guidelines of Table 6.2.
- e. Radiographic (x-ray) procedures are also exempt from the restricted area radiation dose rate ALARA action levels specified above.

6.8 RADIOLOGICAL SURVEY REQUIREMENTS

6.8.1 Documented Monthly Surveys of Authorized Use Locations

The PI is responsible to ensure that areas where unsealed radioactive materials are used or stored are surveyed on a minimum frequency after use, unless no use of unsealed radioactive materials occurred in that location during the month. This survey must be documented on the Radiological Survey Form (RSF), or an RSO approved equivalent.

Perform a radiological survey as follows:

- a. Prepare a diagram of the room or location to be surveyed on a RSF. At a minimum, the diagram should include the general layout of the room or location. Radiological work areas, fume hoods, storage areas, waste containers, etc. should be noted on the diagram. The building, room number and Principal Investigator must be listed on the form. It is recommended that a prepared form be maintained electronically, or be hand drawn once and photocopied for future use to promote efficiency.

- b. Prepare instruments for use in accordance with section 6.4.1 of this procedure.

Note: The performance of radiation dose rate surveys is not required in authorized use locations where the radioactive materials are limited exclusively to milliCi quantities of isotopes that emit primarily beta radiation with energies below 250 keV (H-3, C-14, S-35, and P-33). The exclusive use of I-125 immunoassay kits with <25 microCi per kit is also exempted. Monthly radiological surveys of these locations are only required to include contamination surveys by wipe testing.

- radioactive materials are stored or typically used (waste containers, hoods, benchtops, freezers, etc.) throughout the survey location.
- d. If all 30 cm radiation levels are <0.05 mr/hr, you may record this data on the RSF by using the statement “all dose rates are <0.05 mr/hr.”
- e. If the radiation levels at 30 cm are >0.05 mr/hr but <2mr/hr, record the actual (as found) dose rate on the survey diagram in locations on the diagram that correspond to the survey points. Any individual survey points that are <0.05 mr/hr should be recorded as “<0.05.”
- f. If the radiation survey is performed in an unrestricted area and the 30 cm dose rates exceed 0.05 mr/hr, control access to the affected area and notify Radiation Safety for assistance.
- g. In the event an instrument is used for a restricted area survey that will not detect 0.05 mr/hr, you should use the lowest value that the instrument will detect when recording dose rates in the manner listed above. For example, if the lowest range of an instrument is 0.2 mr/hr, and no increase is noted during the survey, record results as <0.2 mr/hr.
- h. If the 30 cm dose rates are >2 mr/hr but <5 mr/hr, the surveyor should perform the following:
- Locate the radiation source.
 - Determine the contact, 30 cm, and 1 meter dose rates of the primary radiation source that is producing the radiation levels. The results should be recorded on the RSF in the format: contact / 30 cm / 1 meter.
 - If appropriate, relocate the source to reduce the dose rates.
 - If appropriate, shield the source to reduce the dose rates.
 - Perform additional radiation surveys to verify that the dose rates have been reduced to <2 mr/hr at 30 cm and record the results on the survey form.
- i. If the 30 cm dose rates cannot be reduced to <2 mr/hr or are >5 mr/hr, control access to the affected area and notify Radiation Safety for assistance.
- j. Perform a representative number of wipe tests in accordance with your professional judgment with consideration given to the type, quantity, and locations of radioactive materials use that has occurred since the last survey. 10 to 20 wipe test locations are generally appropriate for a typical radioisotope use laboratory. No more than 5 wipe test locations would be appropriate for a location used exclusively for sample counting, such as a LSC room where no other radioisotope work is performed. Recommended wipe test locations include the following:
- areas normally used for radioisotope work (countertops, hoods, sinks, etc.)

- adjacent areas with the potential to have become contaminated
 - floor locations in high traffic areas (hallways, doorways) and in areas adjacent to locations where radioisotopes are commonly handled (in front of hoods, sinks, benchtops, etc.)
 - items frequently handled when moving from radioisotope use/storage areas to unrestricted areas (doorknobs, freezer handles, etc.)
 - exterior surfaces of radioactive waste containers
 - boundaries between restricted and unrestricted areas.
- k. You may use large area wipes to supplement 100 cm² wipe tests during the performance of monthly surveys. To use this option you must follow the requirements of section 5.3 of this chapter.
- l. When performing wipe surveys, it is recommended that you survey areas with the least potential for contamination first and work your way to areas with the greatest potential for contamination last. This reduces the potential for cross contamination of wipes and survey locations.
- m. Wipe test locations may be identified on the map by using circled numbers, or as otherwise described on the RSF.
- n. Analyze the wipe samples in an appropriate counter, document the results, and compare the wipe test results to the ALARA action levels of Table 6.1 of this chapter.
- o. If the ALARA action levels for transferable contamination are exceeded, take the following actions:
- If unrestricted area contamination levels exceed 200 dpm/100cm² but are less than 1000 dpm/100cm²; perform decontamination, re-survey, and document the results on the survey form. In the comments section of the survey form indicate that the affected areas were decontaminated and resurveyed.
 - If unrestricted area contamination levels exceed 1000 dpm/100cm²; prevent personnel access to the affected area and promptly contact Radiation Safety for assistance.
 - If restricted area contamination levels exceed 1000 dpm/100cm² but are less than 10,000 dpm/100cm²; perform decontamination, re-survey, and document the results on the survey form. In the comments section of the survey form indicate that the affected areas were decontaminated and resurveyed.
 - If restricted area contamination levels exceed 10,000 dpm/100cm²; prevent personnel access to the affected area and promptly contact Radiation Safety for assistance.

- If decontamination is widespread or is not reduced after three decontamination attempts; prevent personnel access to the affected area and promptly contact Radiation Safety for assistance.
- p. Document results on the RSF. Keep a copy of the RSF for your records and submit the original to Radiation Safety to be maintained in project files.

Flow Chart for the Performance of a Monthly Radiological Survey in a Restricted Area

Prepare a Radiological Survey Form (RSF) with a diagram of the area and ensure that your radiation monitoring instruments are ready for use.

Are you exempted from performing radiation dose rate surveys as described in of this chapter?

Yes

No

Perform wipe tests of locations that have the potential for contamination. Record the wipe test locations on the survey diagram.

Measure the radiation dose rates at 30 cm (1 foot) from waste containers, radioactive materials storage areas, known radiation sources, and use locations.

Count the wipes with an appropriate instrument.

Are all 30 cm dose rates < 0.05 mr/hr?

Yes

No

Do any wipe results exceed 1000 dpm/100 cm²?

Record "all dose rates are < 0.05 mr/hr" on the survey diagram.

Do any dose rates exceed 2 mr/hr @ 30 cm?

Yes

No

Yes

No

Decontaminate and re-survey the affected area. Contact Radiation Safety for assistance if needed.

If the dose rates are < 5 mr/hr, determine and record the contact/30 cm/1 meter dose rates. Take appropriate measures to reduce the dose rates to < 2 mr/hr @ 30 cm and record the results.

Record the actual radiation dose rate readings in locations on the diagram corresponding to the survey points. Individual survey points that are < 0.05 mr/hr should be recorded as " < 0.05 " on the diagram.

If the dose rates cannot be reduced to acceptable levels or are ≥ 5 mr/hr @ 30 cm, control access and notify Radiation Safety.

Evaluate any areas < 1000 dpm/100 cm² but > 200 dpm/100cm², decontaminate as appropriate (ALARA).

Record all data on the RSF. Keep a copy of the RSF for your records and send a copy to Radiation Safety.

6.8.2 *Surveys for Release to Unrestricted Use*

- a. Potentially contaminated items, components, or areas must be surveyed prior to being released for unrestricted use. This includes items which have been in contact with, or in the near proximity of unsealed radioactive materials. Small hand carried items that have the potential for contamination should be surveyed to the limits specified in this procedure for unrestricted use by the AU, Advanced Radworker, or designee. Routine checks of these small items are not required to be documented on a Radiological Survey Form.

Note: In most cases, a member of the Radiation Safety staff will perform surveys for release to unrestricted use for the items or locations listed below. However, a survey by any qualified PI or AU that is properly performed and documented may be approved by the RSO or designee as a suitable record of release to unrestricted use.

- b. The following items, locations, or components must have a documented radiological survey performed and approved by the Radiation Safety Officer or designee prior to being released for unrestricted use:
 - Authorized use locations, radiological use laboratories, or posted radioactive material areas in radiological use laboratories (bench tops, hoods, sinks, etc.).
 - Large components or equipment that has been used with radioactive materials (freezers, refrigerators, centrifuges, etc.) and are potentially contaminated.
 - Furniture that has been used for radioisotope work, including desktops, cabinets or drawers used to stored radioactive materials or potentially contaminated laboratory items (glassware, pipettes, etc.).
- c. Perform surveys for release to unrestricted use as follows:
 - Perform a direct scan survey of all accessible surfaces with the potential to be contaminated in accordance with section 6.5. of this procedure.
 - The use of a thin window GM pancake type detector and an instrument sensitivity and background of <0.05 mrem/hr is required for the performance of unrestricted release surveys, unless otherwise approved in writing by the RSO. The use of a low energy gamma detector may be needed if isotopes such as I-125 and Cr-51 are known to be present.
 - If contamination is detected via direct scans, determine the location of the contamination and evaluate the possibilities for decontamination.
 - Collect and analyze a representative number of wipe samples as described in this section of the procedure.
 - Document results on the Radiological Survey Form, if required per item 2 above.

- Compare survey results to the unrestricted release values of the following table.

Table 6.3.

Unrestricted Release Limits	
Direct Scan Limit	Transferable Contamination Limit
<2 times background not to exceed 0.05 mrem/hr	<200 dpm/100cm ² (<66 cpm/wipe)

- If the survey results exceed the specified values; decontaminate in accordance with the section re-survey, and document results
 - If the results are below the limits specified in Table 6.3. the material is suitable for release to unrestricted use
 - If the material meets the criteria where a documented survey is required as described in item 2 above, provide a copy of the survey to the Radiation Safety Officer or designee for approval prior to release for unrestricted use. Keep a copy of the survey for your records.
 - Destroy or deface any radiological markings prior to releasing items for unrestricted use.
- d. Liquids, bulk material, and components with inaccessible surfaces with the potential for contamination require special survey techniques or analysis. Contact the RSO or designee for release of these materials to unrestricted use.

6.8.3 Other Survey Requirements

The frequency of radiological surveys in the work place must be adequate to ensure that personnel exposure to radiation and radioactive materials is ALARA. Documentation of these surveys on a RSF is not required. Specific instances when monitoring is needed include, but are not limited to, the following:

- monitoring of conditions during work with radioisotopes
- surveys of work areas after handling radioisotopes
- personnel contamination monitoring (direct scans of hands, clothing, shoes) after working with any unsealed radioactive materials and prior to exiting the laboratory
- direct scans of lab coats, furniture, and other routinely used and potentially contaminated items
- surveys of laboratory equipment after being used with radioisotopes
- radiation surveys of storage areas and waste containers after adding radioactive materials to those locations, to verify that dose rates are within limits

- surveys to ensure that unrestricted areas (i.e. office or break areas) are free from radiological hazards
- surveys in support of radioactive material shipments or transfers
- surveys of waste containers prior to pick up by the Radiation Safety Staff
- monitoring in support of any suspected spill of radioactive materials

6.8.4 Use of the Radiological Survey Form

- Not all surveys have to be documented on a RSF. Examples of surveys that do not require documentation include routine work area surveys and personnel contamination monitoring. Also, surveys in support of radioactive material shipments or transfers may be documented on paperwork other than a RSF. Duplicate documentation of these surveys is not necessary.
- As a general rule, monthly surveys and surveys of potentially contaminated items for release to unrestricted use are the only surveys required to be documented by an AU (or their designee) on a RSF. When in doubt about the need to document a survey consult with the Radiation Safety staff.
- A radiological survey is not required if no use of radioactive materials in an unsealed form is performed in an authorized use location during a calendar month. This information should be reported to Radiation Safety by use of an RSO approved electronic reporting method or by sending in a Radiological Survey Form with a statement in the Comments section denoting that no radioactive materials use occurred. In the case of an Authorized User with multiple rooms approved for radioactive materials use, only those rooms where unsealed radioactive materials were used during the calendar month are required to be surveyed. Individual rooms that do not require a monthly survey should be noted on the RSF so that all approved rooms are accounted for.
- The Radiological Survey Form should be completed in an electronic format for increased efficiency. The electronic format must be approved by the RSO and obtained from Radiation Safety. After the electronic form is completed it must be printed and signed. The signed original copy must be sent to Radiation Safety to be reviewed and stored with project files. Laboratory copies may be maintained in either electronic or hard-copy format.
- If the electronic format Radiological Survey Form is un-available or is not being used for any reason, a radiological survey may still be documented on a paper copy of the form. Some calculations will have to be performed manually. Contact Radiation Safety for assistance if needed.

7 RADIOLOGICAL POSTINGS

7.1 GENERAL POSTING INFORMATION

7.1.1 *Regulatory Documents and Notices*

- a. Current copies of the University of North Texas Radioactive Materials Licenses, 25 TEXAS ADMINISTRATIVE CODE Part 289: Texas Regulations for the Control of Ionizing Radiation, this Radiation Safety Manual, and other radiation safety program documents may be examined at the Radiation Safety Office; Risk Management Services.
- b. In the event that the Texas Department of State Health Services issues a notice of violation involving radiation safety, it will be posted within two working days after receipt of the document from the Department. In addition, the response to any such notice shall be posted for a minimum of five working days or until corrective action has been completed, whichever is later. These notices and responses will be posted and available for examination at the Radiation Safety Office; Risk Management Services.

7.1.2 *Radiological Postings*

- a. Radiological postings shall be used to alert personnel to the presence of radiation and radioactive materials and to aid them in minimizing exposures and preventing the spread of contamination.
- b. Signs shall contain the standard radiation symbol (trefoil) colored magenta or black on a yellow background. Lettering shall be either magenta or black. Magenta is the preferred color over black. All posting signs and labels should be of the same design and consistent with industry standard postings. Signs and labels should not be altered or defaced in any way to change their meaning.
- c. Signs shall be conspicuously posted, clearly worded, and may include radiation safety instructions.
- d. Radiological postings should be displayed only to signify actual or potential radiological conditions. Signs used for training should be clearly marked, such as "For Training Purposes Only."
- e. Postings should not be positioned to obstruct other safety or security signs, markings, or equipment.
- f. If more than one radiological condition (such as radioactive materials and radiation) exists in the same area, each condition should be identified. When appropriate, signs should be placed in order from greatest to least significant radiological hazard.
- g. When required, boundaries for posted areas should consist of permanent structures (such as walls or fences) or specific radiological demarcations (such as yellow and

- magenta rope, chain, or tape). A continuous boundary (except for a designated entry/exit) is required for posting of High Radiation and Contamination Areas.
- h. Posting of doors should be such that the postings remain visible when doors are open or closed.
 - i. A radiological posting that signifies the presence of an intermittent radiological condition should include a statement specifying when the condition is present, such as “Caution: Radiation Area When Red Light is On.”

7.2 POSTING WITH SIGNS

7.2.1 *Laboratory Door Signs*

A caution sign shall be posted at each laboratory entrance door where radiological hazards are present. Risk Management Services provides standard placards for all laboratory entranceways. Radiological postings, as well as other hazard signs, should be affixed to the placards as appropriate for the individual laboratory.

The sign shall include, in addition to the standard radiation symbol and wording, any special precautions to be observed when entering the area and the name of a person to be contacted in case of emergency.

Signs of this type may be obtained from Risk Management Services.

7.2.2 *Other Types of Signs*

The following signs should be used at the entrance door, or within the laboratory, as appropriate for the locations and radiological hazards present or likely to be present in the affected area.

- a. Notice to Employees
The Texas Department of State Health Services, Radiation Control Program form “Notice to Employees”, or an RSO approved equivalent shall be posted where licensed radioactive materials are used or stored.
- b. Caution-Radioactive Materials
This sign shall be posted where licensed radioactive materials are used or stored.
- c. Caution-Radiation Area
This sign shall be posted in any location, accessible to individuals, where the radiation levels could result in an individual receiving a radiation exposure in excess of 5millirem in any one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.
- d. Caution-High Radiation Area
 - This sign shall be posted at the boundary to any location, accessible to individuals, in which the radiation levels could result in an individual receiving a radiation exposure in excess of 100millirem in any one hour at

30 centimeters from the radiation source or from any surface that the radiation penetrates.

- High radiation areas require specific controls such as physical boundaries, warning devices, interlocks, etc. or shall be locked or continuously guarded to prevent unauthorized entry.
 - Signs for devices, which emit ionizing radiation capable of producing a high radiation area only when turned on (x-ray devices) should include an additional description such as “when unit is operating”, or an RSO, approved equivalent.
 - The Radiation Safety Officer, or designee, shall be notified prior to the conduct of any work activity that is planned or suspected to result in the production of any high radiation area that has not been previously approved.
- e. Caution-Contamination Area
- This sign should be posted for areas accessible to personnel entry that exceed the ALARA action levels for transferable contamination as described in this manual.
 - Refer to Chapter 6, for additional information regarding transferable contamination action levels and appropriate actions.
 - This sign will normally be used only as a temporary measure, pending decontamination of the affected area.
 - Contamination on the interior surfaces of closed containers or components should be posted with a radioactive materials tag or label instead of a contamination area sign.
- f. Caution-High Intensity X-Ray Beam
- This sign shall be posted or adjacent to each x-ray tube housing so as to be clearly visible to any individual who may be working in close proximity to the beam path.
 - This sign applies to non-medical open beam x-ray equipment.
 - Additional information about postings for x-ray devices may be obtained from the Texas Department of State Health Services, Radiation Control Program.

7.2.3 POSTINGS WITH TAGS, LABELS AND TAPE

Radiological tags, labels, or tape shall be used when there is a need to caution personnel regarding radiation or contamination hazards from specific items and it would be impractical to use the larger signs normally used for radiological postings.

The following instructions apply to the use of tags, labels, and tape:

- a. The most commonly needed tags and labels have the standard radiation symbol and the words “Caution, Radioactive Material.”

- b. As a rule, locations within posted laboratories that can be closed (freezers, refrigerators, fume hoods, cabinets, etc.) require posting if radiological hazards lie within.
- c. Radiological tags or labels should be used to label items with internal or potential internal contamination.
- d. In addition to the standard radioactive material markings, labeling of containers of radioactive material should include the isotope, quantity, and assay date.
- e. Items, which do not contain radioactive material, are not contaminated, or are not likely to become contaminated or to contain radioactive material, should not be posted with radiological markings even if they are used for radiological work. For example, a balance that is kept clean and free of contamination that is used to weigh radioactive materials contained in Petri dishes need not be labeled. A mechanical pipette device dedicated for use with liquid radioisotopes would be appropriate to label (or to keep in a labeled stand or enclosure) due to the potential for internal and external contamination of the device.
- f. Packaged radioactive material should have the label or tag visible through the package or affixed to the outside.
- g. Labeling for sealed sources should include the isotope, quantity, and assay date. Sources, which are too small to be labeled with all of the stated information, should be labeled, at a minimum, with the words “Caution, Radioactive Material” and the standard radiation symbol.
- h. Radiological warning tape, consisting of yellow and magenta striping with the standard radiation symbol, and/or “Caution, Radioactive Material” tape, should be used as a demarcation of the boundaries of small work areas. An example is a designated area on a bench top covered with absorbent paper and used for radioisotope work. Dedicated radiological work surfaces should not be used for non-radiological work. All items within the boundaries of this type of posted area should be considered potentially contaminated until proven otherwise by a radiological survey.
- i. Instrumentation or equipment that contains radioactive materials shall be labeled with the words “Caution, this instrument contains Radioactive Materials” or an RSO approved equivalent.

7.3 POSTING AND LABELING OF RADIOACTIVE WASTE CONTAINERS

- a. When a waste container is in use, post the container with a “Caution Radioactive Material” label/tag.
- b. Waste container labels should include the isotope(s) and estimated maximum quantity (i.e. mCi amount).
- c. Waste containers that are empty should be labeled as such.
- d. Complete the appropriate paperwork for each waste container in accordance with Chapter 10, Radioactive Waste Handling and Disposal.

- e. The use of a labeled shielding enclosure for a waste container does NOT eliminate the need to label the waste container within.

7.4 EXEMPTIONS TO POSTING REQUIREMENTS

The following items/locations are not required to be posted in accordance with this procedure.

- a. Industrial products that contain exempt quantities of radioactive materials, including; smoke detectors, self-illuminated signs, etc.
- b. Naturally occurring radioactive material (NORM) in exempt quantities or concentrations.
- c. Radioactive material shipments that are packaged and labeled in accordance with 49 CFR 172 (DOT regulations).
- d. Any radioactive materials in quantities less than the amounts specified in 10 CFR 20 Appendix B, Table 2.
- e. Individual containers of radioactive materials in quantities less than the amounts specified in 10 CFR 20 Appendix C, as long as the containers are properly controlled to prevent unauthorized access, use, or disposal.
- f. Manufactured products containing exempt radioactive materials as defined by the 25 TEXAS ADMINISTRATIVE CODE Part 289: Texas Regulations for the Control of Ionizing Radiation
- g. Items or situations otherwise exempted from posting as described by the 25 TEXAS ADMINISTRATIVE CODE Part 289: Texas Regulations for the Control of Ionizing Radiation

8 RESPONSE TO RADIOLOGICAL INCIDENTS

8.1 PRECAUTIONS / LIMITATIONS

- a. In situations where personal safety is, or may become, in jeopardy, no radiation safety requirement shall be considered as limiting any action necessary to protect personal health and safety.
- b. In the event of a fire or release of hazardous materials, warn personnel in the affected area, evacuate the area, call 911, and follow the directions of emergency response personnel.
- c. The Radiation Safety Officer and staff may be reached by calling Risk Management Services at 940-565-2109. During off normal working hours, call 911.
- d. Follow all University safety requirements and directions from emergency response personnel during the implementation of all aspects of this procedure.

Note: Radiological incidents such as accidental spills, personnel contamination events, etc. that are handled and reported in accordance with this procedure will NOT result in disciplinary actions to the persons involved unless deliberate misconduct has occurred. Deliberate misconduct does not include accidents or errors, but does include the willful disregard of Radiation Safety policy. Do not hesitate to seek the assistance of the Radiation Safety staff in support of any incident. Failure to report incidents may result in improper actions, violations of policies or regulations, and the unnecessary spread of contamination.

8.2 RESPONSE TO PERSONNEL INJURY IN RADIOLOGICAL AREAS

If a personnel injury occurs in a radioactive materials area, or in the course of performing work with radioactive materials, the followings actions should be implemented:

- a. Medical considerations are of primary importance. Radiological concerns are secondary. Administer first aid within the limits of your training and qualifications. Do not attempt to move the victim unless there are significant hazards in the immediate location. Utilize appropriate precautions for blood borne pathogen control (i.e. use gloves, etc.)
- b. Notify the Principal Investigation or designee. Follow the guidance of the laboratory safety plan for the handling of personnel injuries including notification to emergency response personnel, if appropriate.
- c. Notify the RSO of any actual or suspected personnel contamination involving an injury. Follow the directions provided by the RSO. If Radiation Safety personnel arrive on the scene, provide them with all appropriate assistance and information.
- d. If immediate medical treatment and transport by ambulance is indicated, the Radiation Safety staff or any individual with radiation safety training should take measures to control the spread of contamination. Do not interfere with patient care in the course of radiation safety activities. When emergency response personnel arrive on the scene; offer to assist them by performing monitoring, removing the victims

potentially contaminated lab coat or gloves (PPE), or other appropriate actions. Do not attempt decontamination or removal of PPE of injured personnel without the consent of medical professionals.

- e. A Principal Investigator or Authorized User with a portable monitoring instrument should continuously accompany the patient until a representative of the Radiation Safety staff arrives or all radiological concerns are resolved.
- f. If immediate medical treatment is not indicated, the Radiation Safety staff should perform personnel contamination monitoring of the individual(s) involved. If the Radiation Safety staff cannot arrive promptly, any trained individual (PI or AU) should scan the individual(s) involved for contamination with a portable instrument in accordance with this Manual.
- g. If the individual is cleared of radiological contamination take any additional precautions needed to secure the area of radiological hazards. Document survey information on a Radiological Survey Form or take notes for future reference to report the incident. Documentation should include the individuals name, EUID number, date/time, location, and general circumstances of the event. Perform and document follow up surveys, as appropriate, to ensure that no spread of contamination occurred.

8.3 RESPONSE TO A SPILL OF RADIOACTIVE MATERIAL

8.3.1 Major Spills

A spill is considered a major spill if it involves millicurie quantities of radioisotopes, includes materials with the potential to produce significant airborne radioactivity (mist, dust, fumes), covers a large area (more than a few square feet of area), or if the spill is not easily contained or controlled. Any malfunctions of radiation producing devices (irradiators, large quantity sealed sources, X-ray devices) with the potential to result in high radiation levels should be treated in the same manner as a major spill.

Respond to major spill as follows:

- a. Take no actions, which could result in injury or unnecessary contamination to yourself or others.
- b. Stop work. If necessary, secure any immediate safety hazards.
- c. Warn other individuals in the area. All personnel should leave the immediate area but take appropriate measures not to spread contamination. Potentially contaminated individuals should gather in a location nearby for monitoring prior to being released.
- d. Isolate the area to prevent the spill from spreading.
- e. If any volatile materials are involved or if there is the potential for airborne radioactivity, make sure that fume hoods are operating and that the sash is partially open. Close any available doors to control ventilation. If outdoors, stay upwind.

- f. Secure the area to prevent personnel access. Lock doors, post-warning signs, or post an individual trained in radiation safety to control access to the affected area from a safe distance.
- g. Notify the RSO or any member of the Radiation Safety staff. If they are not available, contact the campus police.
- h. Notify the Principal Investigator or other individuals responsible for the area.
- i. Remain in a safe location until assistance arrives.
- j. Personnel involved should not leave the scene until cleared by Radiation Safety or emergency response personnel.

8.3.2 *Response to Spilled Radioactive Materials on Skin or Personal Clothing*

If radioactive material in a dispersible form is spilled onto a person's skin or clothing take the following actions:

- a. If the contamination is associated with a hazardous material, immediately remove the hazardous material using whatever means are necessary to ensure personal safety.
- b. Notify your lab safety representative as soon as possible.
- c. If the spill is on clothing, immediately remove the clothing and proceed with monitoring of the skin for contamination. When removing clothing use caution not spread contamination to other parts of the body, especially the facial area.
- d. If the radioactive material may have volatile characteristics (radioiodine, S-35, etc), place the contaminated clothing in an operating fume hood or securely closed plastic bag.
- e. If the radioactive material is spilled directly onto skin, immediately rinse the affected area with running water. It is best to use water that is lukewarm. Cold water may cause the pores of the skin to close, trapping contamination within the layers of skin. Hot water may cause the pores to open, causing a potential avenue for contamination to travel deeper into layers of the skin.
- f. Pat the affected area dry with a disposable towel and proceed with contamination monitoring.
- g. Promptly notify the RSO or a member of the Radiation Safety staff of any suspected or confirmed radioactive contamination of the skin or personal clothing.

8.3.3 *Minor Spills*

A minor spill involves a small quantity of radioactive materials and does not meet the criteria described for a major spill. Minor spills that are recognized and properly controlled should not result in personnel contamination.

A minor spill should be handled as follows:

- a. Stop work. If necessary, secure any immediate safety hazards.

- b. Warn other individuals in the area to stay out of the spill location. Notify the PI or AU, they should perform/direct further activities.
- c. If assistance is needed, promptly notify the Radiation Safety staff.
- d. Isolate the area to prevent the spill from spreading. Cover liquid spills with absorbent materials.
- e. Perform contamination monitoring of any individuals with the potential to have become contaminated as a result of the spill. If personnel contamination is indicated or suspected, refer to section 8.4 of this procedure for instructions.
- f. Trained personnel wearing gloves, lab coats, and other appropriate PPE should carefully clean up the spilled material. Remove absorbent materials and place in radioactive waste containers for disposal.
- g. Survey the affected area for contamination in accordance with Chapter 6 of this manual. Compare the survey results to the action levels specified in Chapter 6 and implement appropriate actions in accordance with that procedure.
- h. If contamination is indicated, decontaminate the affected area as described in section 8.3.4 or contact the Radiation Safety staff for guidance.
- i. When contamination is below limits, record the survey on a Radiological Survey Form. Document both the “as found” contamination levels and the final levels following decontamination.
- j. Provide copies of the survey results to the Radiation Safety Office.

8.3.4 Decontamination of Areas and Equipment

Area or equipment decontamination (decon) should be performed as follows:

- a. Wear PPE (lab coat & gloves), control access to the area, and do not allow personal clothing or unprotected skin surfaces to contact potentially contaminated surfaces during decontamination or when performing post-decon surveys.
- b. Locate the approximate boundaries of the contaminated area by radiological survey (direct scans, wipe testing).
- c. Mark the boundaries with a temporary marking of tape or by a similar method.
- d. Carefully clean the affected location using commercial cleaning materials and disposable wipes. Do not use volatile solvents or larger than necessary quantities of water or cleaning solutions.
- e. If using cleaners applied by spray, do not spray directly onto contaminated surfaces at a close proximity to the surface. Aggressive spray techniques may spread the contamination.
- f. When wiping with disposable towels, it is often useful to wipe the most highly contaminated section first, covering the smallest practical area and immediately discarding that towel. Then wipe from the outer boundary (less contaminated) toward the center (more contaminated) of the contaminated area. Make single passes when wiping and use a new surface of the towel for each wipe. An inward spiraling

circular motion is often effective. The method used should prevent spreading the contamination.

- g. Dispose of all waste properly. Wet contaminated towels should be placed in a dry radioactive waste container with sufficient absorbent material to prevent any visible liquid from developing.
- h. Perform follow up surveys and continue decontamination efforts if needed.
- i. Perform personnel contamination monitoring after each decon effort.
- j. If three attempts at decontamination are unsuccessful, you should use different decontamination agents or methods. Contact the Radiation Safety staff for assistance as needed.
- k. Decontamination is considered complete when a radiological survey indicates that contamination is below appropriate limits, waste materials have been properly disposed of, and surveys have been documented.

8.4 RESPONSE TO SUSPECT PERSONNEL CONTAMINATION

8.4.1 *Precautions*

- a. Verify that no personnel injury has occurred, if the contamination is related to a personnel injury, follow the instructions of section 8.3 of this procedure.
- b. If the contamination is associated with a hazardous material, immediately remove the hazardous material using whatever means are necessary to ensure personnel safety. Notify the lab safety representative as soon as possible.
- c. If the personnel hazard is not immediate, perform and document contamination survey information prior to removal of the material by decontamination.
- d. Always notify the Radiation Safety staff of any suspect or confirmed contamination of skin or personal clothing.
- e. Whenever possible, the affected individual should seek the assistance of another trained Radiation Worker, an ARW, or the AU in handling the situation and in contacting the Radiation Safety staff.
- f. Stay calm. Remember that the health risks are minimal from personnel contamination with the typical quantities and concentrations of radioisotopes used at UNT. A minor delay to take appropriate actions is insignificant compared to the risk of overreacting and causing a personal injury or the spread of contamination.

8.4.2 *Personnel Contamination Monitoring*

Perform personnel contamination monitoring as follows:

- a. Turn the instrument scale to the lowest setting and allow the instrument to stabilize to area background. Personnel contamination monitoring should be performed in an area with the lowest available background radiation levels.
- b. SLOWLY scan (approximately 2 inches per second) with the detector of the instrument at a distance of approximately 1/2 inch from the surface being monitored.

- c. Monitor your hands first to ensure that you do not spread contamination.
- d. Survey all other areas of the body and clothing with the potential for contamination. This should include, but is not limited to, the front of the torso, elbows, arms, face, and shoes (top and bottom).
- e. If an audible increase in the count rate is heard, or if the meter reading increases, hold the detector still over that location for 5 to 10 seconds and determine if the reading is higher than the background level.
- f. If contamination is indicated as in item 5 above, it is best to stay where you are to prevent the spread of contamination and have someone assist you in notifying the RSO or a member of the Radiation Safety staff. While waiting for assistance, avoid unnecessary contact between areas of suspected contamination and “clean” surfaces.
- g. If no contamination is detected, evaluate the situation to determine if additional work area surveys or monitoring of other personnel is indicated.

8.4.3 *Response to Personnel Contamination Events*

- a. If contamination of skin is confirmed, always notify the RSO or a member of the Radiation Safety staff.
- b. Before beginning decontamination, attempt to determine the location and approximate size of the contaminated area. Record the maximum reading found with the instrument at a distance of ½” (near contact) from the contaminated area. For fastest results, simply write down the instrument reading and the scale used. In the event that the instrument reading is off-scale at contact, attempt to obtain and record an on-scale reading at a measured distance away. A pencil, pen, or piece of paper may be used to “measure” the distance since this will provide a reference to be measured at a later time. Also note the time (or best estimate) of the initial contamination occurrence. This information is needed to assist in calculating an accurate assessment of the amount of radiation exposure to the skin.

<u>Example:</u>	Time	9:15am
Approximate size/location	2 square inches, right forearm	
Instrument contact reading	3.5	
Instrument scale	x 0.1 (mr/hr)	

- c. Simple skin contamination can usually be removed by washing the affected area with soft soap and lukewarm water. Make sure that you do not spread the contamination to other areas of the body during the decontamination process.
- d. Dry the area by patting lightly with a disposable towel. Re-survey the affected area immediately following decontamination. If necessary, repeat decontamination by soap and water.
- e. When there is no detectable contamination remaining, record the time of the survey.

- f. If three consecutive decontamination attempts using soft soap and water are not successful, additional measures such as an industrial grade hand cleaners may be used.
- g. Do not abrade the skin, use harsh chemicals, or attempt decontamination of injuries, the eyes, or body orifices without the assistance of medical professionals and the RSO or designee. However, if no medical complications are apparent, injuries, eyes, or body orifices may be flushed with lukewarm water or saline solution to promptly remove any hazardous materials or radioactive contamination from the affected area. Use precautions not to spread the contamination and capture any rinse water in a suitable container. The rinsate may require analysis in support of a radiation exposure assessment.
- h. Any facial contamination, contamination-involving breaks in the skin, or contamination with the potential for skin absorption or internal contamination will require a determination by the RSO of the need for a bioassay.
- i. If necessary, restrict and control access to any work locations where contamination events have occurred until follow up surveys can be completed.
- j. The Radiation Safety staff should perform a preliminary evaluation of incidents to determine the potential causes and to take measures to ensure that no additional personnel contamination events occur as a result of existing conditions or circumstances.

8.5 FOLLOW UP ACTIONS FOR RADIOLOGICAL INCIDENTS

- a. Document radiological surveys on a Radiological Survey Form or an RSO approved equivalent.
- b. A Radiological Improvement Program Report (RIPR), or an RSO approved equivalent, should be used for reporting and tracking of significant radiological incidents.
- c. RSC and DNR notification of incidents will be performed by Radiation Safety in accordance with regulatory requirements and as described in Chapter 11, Radiological Improvement Program.
- d. A critique should be conducted for significant incidents. At a minimum, participants of the critique should include the individuals involved in the incident, the PI, and the RSO or designee. The critique should focus on determining why the event occurred with the goal of determining the appropriate path forward to prevent future occurrences.

9 LABORATORY PROCEDURES

9.1 RADIATION SAFETY TRAINING

9.1.1 Radiation Worker Training

All individuals who work with radioactive materials at the University are considered Radiation Workers (Radworkers). Individuals who routinely occupy or frequently work in locations where radioactive materials are used or stored may also be considered Radworkers. All Radworkers must receive documented training in radiation safety. The Radiation Safety Office maintains all records for radiation safety training. It is the responsibility of the Principal Investigator to ensure that this training has been completed. Radworker training should be completed prior to the performance of any tasks using radioactive materials or involving radiation exposure. The minimum requirements for Radworker training shall include:

- Reading this Manual.
- General rules of radiation safety.
- Specific rules for the authorized uses and use locations.
- Directions for contacting the Radiation Safety Officer and Radiation Safety Staff for assistance.
- Directions for notifying the proper authorities in the event of an emergency or accident.

9.1.2 Visitors, Members of the Public and Maintenance Personnel

Visitors, members of the public, and maintenance personnel should not be allowed access to radioactive materials or radiation sources. However, if such personnel should have a justifiable need to perform tasks associated with, or in the vicinity of radioactive materials, they must be adequately protected and informed of the radiation hazards. Radiation exposure to non-Radworker personnel must be kept to minimal levels (<100 mrem/year from all licensed sources). In most cases, a trained Radworker should provide direct and continuous guidance for such activities. If this is not practical, appropriate measures must be taken to control access to radiation hazards or radioactive materials, or to perform radiological surveys and release locations or components to unrestricted use.

9.2 RADIOLOGICAL WORKING PLANNING

- a. Plan the layout of the laboratory in relation to your radiological work. When practical, locate all radiological use and storage areas in the same part of your laboratory. The exception to this is to allow adequate distance from radiation sources to reduce personnel exposure.
- b. Use the smallest reasonable quantity of radioactive material for the desired purpose.

- c. When a choice of radionuclide is available, use the least hazardous radioisotope for the planned experiment.
- d. Do not order more radioactive material than needed for the anticipated use. Handling of excess material may increase personnel exposure. Also, regardless of half life, all compounds containing radioactivity undergo decomposition as a result of radiation effects.
- e. Prior to the individual performance of a first time operation, practice the task with inert (non-radiological and non-hazardous) materials. This is especially important for delicate operations or when working with larger than normal quantities or concentrations of radioisotopes.
- f. Verify that all needed equipment, instrumentation, and supplies are available and operational prior to beginning radiological work.

9.3 RADIOACTIVE MATERIAL SECURITY

Federal and state regulations require that radioactive material be kept secure from unauthorized access. This requirement applies to all licensed (non-exempt) radioactive materials. See Chapter 7 of this manual, Radiological Postings for additional information about exempt radioactive materials. You may meet this security requirement by using one or more of the following options:

- keep the doors locked for all rooms where radioactive materials are located,
- keep all radioactive materials (including waste) in locked enclosures, and/or;
- ensure that all radioactive materials are continuously controlled by individuals with training in radiation safety who are willing to challenge other personnel who might be attempting unauthorized access

Radioactive material in the form of small quantity sealed sources that are an integral part of a non-portable piece of equipment (i.e. liquid scintillation counters and gas chromatographs) are considered secure from unauthorized access when the equipment is located in an authorized use location.

Note: Any lost or missing radioactive materials must be reported to Radiation Safety immediately.

9.4 ENGINEERING CONTROLS

Engineering controls are the physical equipment and mechanical devices used for control of radiological hazards. Engineering controls facilitate the safe performance of radiological work and can reduce the need for restrictive personnel protective equipment.

- a. Radioactive materials that are handled or used in unsealed forms should be confined to control the release of materials and to prevent the spread of contamination.

- b. Use trays and/or absorbent surface covers (secondary containment) to catch and retain spilled materials in all appropriate radioisotope work locations.
- c. Plastic bags may be used for temporary storage of lab ware or associated contaminated items. The bags should be labeled and only used for short periods of time until the potentially contaminated items are surveyed “clean” of contamination, decontaminated, or held for radioactive decay.
- d. Use secondary containment devices for any bulk storage of liquid radioisotopes. This should include the use of trays or bins under your liquid waste carboys to contain spills or leakage.
- e. The use of an approved fume hood is required for any activity likely to generate dust, fumes or vapors containing radioactive materials.
- f. Fume hoods should be used when working with volatile radioactive materials, and when initially opening vials containing milliCi quantities of radioisotopes.
- g. Use radiation shielding when working with gamma or high-energy beta emitting radioisotopes to keep dose rates ALARA.
- h. Store radioisotopes in the original shipping container, or in a container that provides equivalent or better radiation shielding than the original shipping container.
- i. Survey radioactive material use, storage, and waste container locations for radiation dose rates, as described in Chapter 6, Radiological Surveys. If significant radiation levels are found at 1 foot from the source, use shielding to lower the work area radiation levels. Contact Radiation Safety for assistance if necessary.
- j. High-energy beta emitting isotopes such as P-32 should be shielded with low density materials such a plastic, plexiglass, or Lucite. This type of shielding is commercially available through lab safety suppliers.
- k. Gamma emitting isotopes (I-131, Cr-51, Fe-59, etc.) are best shielded with dense materials such as lead bricks, blocks, or sheets. However, use caution when handling or working with lead. Lead (Pb) is considered a hazardous material due to risks of inhalation, ingestion, or absorption of this heavy metal into the body.
- l. Use remote handling tools in the form of work stands, tongs, tweezers, etc. to reduce exposure to the extremities (hands & fingers) and whole body when appropriate.

9.5 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personal protective equipment is clothing and equipment that is worn for reducing exposure to workplace hazards.

- a. Personnel handling unsealed radioactive materials consider lab coats and disposable gloves the minimum acceptable PPE for use.
- b. Appropriate footwear with a closed toe (no sandals) must be worn when working with radioactive materials that have the potential to be spilled on the foot.

- c. If PPE is required for both radiological and laboratory safety purposes, the PPE that provides the greatest protection should be used.
- d. The use of double gloves (two pair) is encouraged and should be considered mandatory when working with isotopes that can be absorbed through the skin (i.e. tritiated water, radioiodine).
- e. Eye protection in the form of safety glasses or face shields should be used by persons performing operations with the potential for liquid splash, or during the conduct of procedures that might otherwise result in contamination of the eye.
- f. Eye protection is also required when handling P-32 (or other high-energy beta emitters) in individual quantities >1 millicurie to reduce the amount of Beta radiation that reaches the eye.
- g. Radiological use PPE should not be worn outside of a posted radioactive materials area or radiological use laboratory. When transporting radioactive materials outside of posted areas, the radioactive materials should be packaged or contained in a manner such that no PPE is necessary.
- h. Gloves should be monitored periodically during work with radioisotopes. Contaminated gloves should be promptly removed. After removal of contaminated gloves, monitor the inner pair of gloves (or skin surface, if only 1 pair is used) for contamination. If skin or personal clothing contamination is detected, take appropriate actions as described in Chapter 9, Response to Radiological Incidents.
- i. Lab coats should be scanned for contamination at a minimum frequency of weekly, at any time contamination is suspected, and prior to laundering. The ends of the sleeves, front of the lab coat, and pockets are likely locations for contamination to be present. If contamination is detected on a lab coat due to short lived radioisotopes, it may be bagged, labeled, and stored for decay. If the contamination is due to long lived radioisotopes, contact Radiation Safety for recommendations on decontamination. A replacement lab coat should be used until radiological surveys indicate no detectable activity on the previously contaminated lab coat.
- j. The exemptions to personnel contamination monitoring detailed in section 6.0 below also apply to monitoring of PPE described in this section.

9.6 PERSONNEL CONTAMINATION MONITORING

Personnel contamination monitoring is the only practical method to ensure that your skin or personal clothing is not contaminated with radioactive material. Neglecting to perform monitoring can result in the spread of contamination and increases the risk of inhalation, ingestion, or absorption of radioactive material. Personnel contamination monitoring is commonly referred to as “frisking” in the field of radiation protection.

The following requirements apply to personnel contamination monitoring.

- a. Personnel contamination monitoring is required prior to exiting a radiological use laboratory after handling unsealed radioactive materials.

- b. Personnel contamination monitoring should be performed upon the completion of any single operation involving the handling of unsealed radioactive materials.
- c. The minimum standard for personnel contamination monitoring consists of a slow scan with the probe of a portable monitoring instrument, checking the hands, shoes, and any other areas of the body or clothing with the potential to have become contaminated during the operation conducted.
- d. After a spill or unplanned contamination event, a “whole body frisk” should be performed. A whole body frisk is a scan of the entire body/clothing for contamination. When properly performed, a whole body frisk takes two to three minutes.
- e. The “hand & foot frisk” involves a scan of the palms, fingers, and thumbs of both hands and the soles of the shoes. This simple task greatly reduces the risk of inhalation or ingestion of radioactive material and ensures that if contamination is present on floors it is not spread to normally “clean” areas.
- f. Perform personnel contamination monitoring in a low background area with the instrument on the lowest scale. A background level <0.05 mr/hr is recommended.
- g. Notify the PI and Radiation Safety office of any instances of skin or personal clothing contamination.
- h. For additional information about personnel contamination monitoring and response to personnel contamination events, see Chapter 8, Response to Radiological Incidents.
- i. This requirement for personnel contamination monitoring does not apply to laboratories using exclusively H-3 or that are exempted from having a portable monitoring instrument in accordance with Chapter 3, Facilities and Equipment Considerations.

9.7 PERSONNEL DOSIMETRY

9.7.1 *Dosimetry Requirements*

- a. Radiation monitoring dosimetry is required for all individuals working with gamma and high energy beta emitting isotopes (P-32, I-125, I-131, Na-22, Tc-99m, Cr-51, etc.) except as noted below.
- b. Radiation Workers without dosimetry may perform limited tasks approved and supervised by a PI or AU. Individuals without dosimetry should not be exposed to dose rates >2 mr/hr. or allowed to frequent areas with dose rates > 0.2 mr/hr. These radiation exposure levels are for whole body dose rates as measured at 30 cm (approximately 1 foot) from the radiation source.
- c. Extremity monitoring (finger rings) is required for all individuals performing operations that involve handling individual quantities >1 milliCi of P-32 or other gamma and high-energy beta emitting isotopes.
- d. Dosimetry is not required for personnel working in laboratories permitted only for millicuries quantities of isotopes, which emit primarily beta radiation with energies

below 250 keV (H-3, C-14, S-35, and P-33). The exclusive use of I-125 immunoassay kits with < 25 μCi per kit is also exempted.

- e. Laboratories where only small quantities (i.e. <250 μCi) of gamma and high energy beta emitting isotopes are handled during single operations, or where radioisotopes are used infrequently need not have all individuals working with the radioisotopes monitored with dosimetry. In these cases, and as otherwise approved by the Radiation Safety staff, only a representative individual(s) responsible for performing the majority of the radiological work should be monitored.
- f. Dosimetry may be discontinued for individual workers on a case by case basis if historical data indicates that exposures are consistently minimal. The Radiation Safety staff will make this determination.

9.7.2 Procurement and Control of Dosimetry

- a. When it has been determined that dosimetry is needed, the individual to be monitored must submit a Dosimetry Request Form (or RSO approved equivalent) to Radiation Safety. Allow a minimum of 2 weeks for the processing of a new request for dosimetry.
- b. Individuals who have had prior occupational radiation exposure at other institutions will need to complete an Individual Radiation Exposure History Data Sheet (or RSO approved equivalent) in order to be badged.
- c. When not in use, dosimetry badges should be stored in a low background area. A designated location for dosimetry badge storage is recommended.
- d. Take care not to contaminate dosimetry badges. If you suspect your badge may be contaminated, promptly notify Radiation Safety.
- e. Immediately report lost, misplaced, or damaged dosimetry to Radiation Safety. An investigation in support of a radiation exposure estimate must be initiated for lost dosimetry.
- f. Radiation monitoring dosimetry is used to determine a legal record of individual radiation exposure received at the University. Never tamper with a badge or wear anyone else's dosimetry.
- g. Do not use your dosimetry when traveling to other institutions without the approval of the RSO or designee. Also, do not wear your dosimetry when away from UNT facilities or during any personal medical care.
- h. Dosimetry badges are typically changed out on a monthly or quarterly cycle. If you are terminating work with radioactive materials you are responsible for returning your dosimetry badge to Radiation Safety in order to ensure that your radiation exposure is properly measured and recorded.

9.7.3 Radiation Exposure Reports

- a. Individual radiation exposure reports will be distributed to monitored personnel on an annual basis.

- b. Individual radiation exposure reports may be requested from Radiation Safety at any time. Requests should be submitted in writing and include the signature of the monitored individual due to the privacy issues associated with radiation exposure reports.
- c. Radiation exposure report summaries may be provided to PIs or supervisory personnel as a part of the ALARA program. Personal information that is inappropriate for distribution (dates of birth, social security numbers) will be omitted or defaced on these reports. However, the data contained in these summary reports should still be considered confidential with respect to individual

9.8 RADIATION SAFETY RECORDS

Records in support of the requirements described in this Radiation Safety Manual must be maintained in the laboratory. These records must be available for review by the Radiation Safety staff or regulatory agencies. Unless otherwise specified, it is recommended that records be organized in labeled binders for easy access and to facilitate the review process. Examples of these records include:

- emergency contact information
- radiation emergency procedure
- radioactive materials permit or initial radioactive materials use approval
- radioactive materials permit amendments
- package receipt and daily use log
- radiological wipe test
- solid radioactive waste log
- liquid radioactive waste log
- quarterly inventory

9.9 SAFE RADIOLOGICAL WORK PRACTICES

- a. No eating, drinking, smoking, applying cosmetics, or handling of contact lenses should be performed in a radiological use laboratory or posted radioactive materials area.
- b. Do not store food, drink, or use/store items for the preparation of food or drink in radiological use areas.
- c. Radioactive material areas posted exclusively for the presence of sealed sources may be exempt from the two requirements listed above, if specifically approved by the RSO or designee.
- d. Please be aware that personnel performing laboratory inspections (either the Radiation Safety staff or representatives of regulatory agencies) may regard the presence of empty food or drink containers in radioactive material areas as evidence of consumption of these products.
- e. Do not work with unsealed radioactive materials if you have any cuts or breaks in the skin with the potential to result in internal contamination. Never pipette by

- mouth. Avoid all activities that are likely to result in the ingestion, inhalation, or absorption of radioactive materials.
- f. Store radioactive materials in clearly labeled containers. Labels should include the isotope, quantity, and date.
 - g. Notify the RSO if you have recently had, or are scheduled to have, any medical treatment involving the internal administration of radioactive materials (not X-rays). Individuals who have recently had a medical internal administration of radioactive materials can have incorrect (excessive) exposure recorded on personnel dosimetry and difficulty in monitoring for radiation or contamination.
 - h. Laboratory workers shall not initiate any changes to experimental procedures using radioactive materials without prior approval of the Authorized User or designee. In addition, any abnormal occurrences in radiological use locations should be promptly reported to the PI or designee. If the PI is not available, Risk Management Services may be contacted for assistance.
 - i. Radioactive materials are only to be used or stored in authorized use locations. Changes to authorized use locations must be processed through the permit amendment process.
 - j. Radioactive waste must be properly packaged, labeled, and controlled. See Chapter 10, Radioactive Waste Handling and Disposal for additional information.
 - k. Perform routine and non-routine radiation and contamination surveys at a frequency adequate to ensure that personnel exposure is ALARA. See Chapter 6, Radiological Surveys for additional information.
 - l. During radiological work, a portable monitoring instrument should be turned on and near the work location. When working in a fume hood, the instrument should be in an easily accessible location outside the hood. This requirement does not apply for laboratories exempted from monitoring as described in section 9.6. of this chapter.
 - m. Potentially contaminated laboratory equipment must be surveyed and determined to be free of contamination in accordance with the requirements of Chapter 6, Radiological Surveys prior to removal from a radioactive materials area.

9.10 SPECIFIC RADIOLOGICAL HAZARDS

9.10.1 Internal Hazards

Contamination occurs when an unsealed radioactive material (liquid or dispersible solid) is in an undesirable location. The primary hazard of contamination is inhalation, ingestion, or absorption of radioactive material into the body. All dispersible radioactive materials may cause contamination and are therefore considered internal hazards. Internal hazards are controlled by surveys and monitoring, engineering controls, and personal protective equipment (PPE).

9.10.2 External Hazards

Radiation is energy, in the form of particles or waves, emitted from radioactive materials. An external radiation hazard occurs only when the amount of radiation emitted is powerful enough to reach and interact with the human body. External hazards are controlled by the principles of time, distance, and shielding.

Time

Less time exposed equals less total exposure. For example a person in a radiation area for 1 hour where the dose rate is 10 mrem/hr will receive a radiation exposure of 10 mrem. If the time spent in the radiation area were reduced to 30 minutes, the individual exposure would be reduced to 5 mrem.

Distance

If you double the distance from a radiation source your exposure is reduced by a factor of four (inverse square law).

Shielding

Increasing the amount of appropriate shielding also reduces the dose rate from a radiation source. Shielding can be in the form of specifically designed materials as discussed in other parts of this manual. In addition, commonly available laboratory materials such as the sash of a fume hood, glassware, water, and shipping containers provide some degree of shielding.

9.10.3 Radioactive Iodine

- a. Radioactive iodine (I-125, I-131) is both an internal and external hazard.
- b. I-125 has a radiological half-life of 59.7 days. I-131 has a radiological half-life of 8.04 days.
- c. Radioactive iodine in an unbound state may readily become airborne, resulting in an inhalation hazard. It may also be absorbed into the body via direct contact with the skin. Once inside the human body, radioactive iodine will concentrate in the thyroid gland.
- d. The most volatile forms are sodium iodide (NaI) and radioiodine in acidic solutions.
- e. Training for users of radioactive iodine should include observing Radworkers experienced in radioiodine procedures, practicing procedures with non-radioactive materials, and demonstrating proper work practices to an experienced radioiodine worker prior to un-supervised performance.
- f. Double disposable gloves (wear 2 pair) are required for radioiodine work.
- g. Only small quantities of radioiodine may be handled on an open bench, such as RIA kits that contain < 25 microcuries. See section 4.1 of Chapter 3 for additional information about fume hood requirements.
- h. Use syringes and needle guides for removal of radioiodine through the septum of shipment vials. Charcoal traps are also available. Follow the vendor's instructions for the use of these products. If the package insert instructions are not available,

refer to vendor catalogs, websites, or call the vendor by telephone for technical information.

- i. Containers of radioactive iodine must be kept tightly sealed at all times to prevent airborne radioactivity. Ziplock style plastic bags should be used to contain small contaminated items. Remember to seal and label the bags.
- j. Fume hoods should be used to reduce the risk of inhalation. The sash of the hood should be kept at the lowest practical level during work.
- k. Monitoring must be performed at frequent intervals to detect and prevent the spread of contamination. A conventional GM probe is very inefficient for the detection of I-125, which emits low energy radiation (electron capture X-rays). A scintillation detector designed for detecting I-125 is the best choice of detector for a portable monitoring instrument. I-131 emits a combination of beta and gamma radiation and is easily detected with portable instruments equipped with conventional GM detectors.
- l. Contamination surveys should include wipe tests analyzed by liquid scintillation counting or by use of a low energy gamma counter.
- m. In addition to contamination surveys, radiation dose rate surveys should be performed in radioiodine laboratories, except for laboratories where only small quantity RIA kits are used. Radiation dose rates should be measured at 1 foot from use areas, storage locations, and waste containers as described in Chapter 6, Radiological Surveys.
- n. Individuals working with radioactive iodine must have thyroid bioassays in accordance with the requirements of Chapter 3, Radiation Exposure Limits. Notify the Radiation Safety staff to schedule a thyroid bioassay.
- o. Any individual who has had skin contamination due to radioactive iodine or has reason to suspect that they may have inhaled, ingested, or absorbed radioiodine should promptly notify the Radiation Safety staff to schedule a thyroid bioassay.

9.10.4 Phosphorus-32

- a. Phosphorus-32 (P-32) is primarily an external hazard, but it is also an internal hazard. P-32 decays by the emission of a high energy beta particle. This intense beta radiation has the potential to result in very significant personnel exposure, especially to the skin and extremities (hands or fingers). The lens of the eye should also be protected from beta radiation by the use of safety glasses or other protective measures.
- b. P-32 has a radiological half life of 14.3 days.
- c. Extremity dosimetry (ring badge) is required for persons performing direct handling of P-32 in individual quantities >1 millicurie.
- d. P-32 should never be directly shielded with dense materials such as lead, due to the Bremsstrahlung effect. Bremsstrahlung radiation is the production of X-rays as a result of charged particle interaction with a dense material. After the high energy

beta radiation has been attenuated by a low density shielding material (plastic, acrylic, etc.), it may be shielded with lead or other high density materials without generating Bremsstrahlung radiation.

- e. Plexiglass, acrylic, or Lucite plastic of 3/8" minimum thickness is recommended for shielding of P-32.
- f. Never work directly over an open container of P-32, since the walls of the container (plastic, glass) provide some shielding for the beta radiation.
- g. Do not handle containers of P-32 any longer than necessary. Use tongs, work stands, and associated devices to limit direct handling.
- h. P-32 is not a significant absorption hazard, but like all unsealed materials may be ingested.
- i. The high energy beta associated with P-32 is easily detected with a portable monitoring instrument using a thin window GM detector (efficiency >30%). Work area surveys for contamination may be performed by direct scans and wipe testing as described in Chapter 7, Radiological Surveys.
- j. In addition to contamination surveys, radiation dose rate surveys should be performed in P-32 laboratories. Radiation dose rates should be measured at 1 foot from use areas, storage locations, and waste containers as described in Chapter 6, Radiological Surveys

9.10.5 Sulfur-35

- a. Sulfur-35 (S-35) is primarily an internal hazard. However, direct skin contact with S-35 can result in significant beta exposure to the affected location.
- b. S-35 has a radiological half-life of 87.2 days.
- c. S-35 has volatile characteristics, especially in the form of cysteine or methionine compounds. Temperature changes promote volatility. Use a fume hood to reduce inhalation risks.
- d. Some chemical reactions with S-35 can generate sulfur dioxide or hydrogen sulfide, both of which are gases and therefore an airborne (inhalation) hazard.
- e. S-35 is not a significant absorption hazard, but like all unsealed materials may be ingested.
- f. Portable survey instruments with thin window GM detectors have a low efficiency for S-35 (approximately 5%), so it is not easily detected by scanning. Direct scanning for contamination must be done slowly (1 to 2 inches per second) in a close proximity (1/2") to the surface being scanned. Contamination surveys should focus on wipe testing with the wipes counted in a liquid scintillation counter.

9.10.6 Phosphorus-33

- a. Phosphorus-33 (P-33) is primarily an internal hazard. However, direct skin contact with P-33 can result in significant beta exposure to the affected location.
- b. P-33 has a radiological half life of 25.3 days.

- c. P-33 is not a significant absorption hazard, but like all unsealed materials may be ingested.
- d. Portable survey instruments with thin window GM detectors have an adequate efficiency for S-35 (approximately 15%), so it is easily detected by scanning. Contamination surveys should focus on a combination of scanning wipe testing with the wipes counted in a liquid scintillation counter.

9.10.7 Tritium

- a. Sealed sources shall be leak tested at a frequency specified by the Radiation Safety Office. A leak testing kit will normally be sent to the Authorized User by the Radiation Safety staff at appropriate intervals.
- b. Tritium (H-3) is an internal hazard. There is virtually no external radiation hazard because the low energy beta radiation emitted is shielded by the outer layer of skin.
- c. H-3 has a radiological half life of 12.3 years.
- d. Because tritium is essentially radioactive water, it may easily enter the body through inhalation, ingestion, or absorption. The most volatile form of tritium is tritiated water.
- e. Tritium will penetrate disposable gloves over time. Wear double gloves and change the gloves often to prevent compromising their effectiveness.
- f. Portable survey instruments will not detect tritium. Survey for tritium by wipe testing and count the wipes in a liquid scintillation counter.
- g. Individuals involved in operations which utilize, at any one time, more than 100 millicuries of tritium in a non-contained form, must have a bioassay performed in accordance with the requirements of Chapter 3, Radiation Exposure Limits.

9.10.8 Carbon-14

- a. Carbon-14 (C-14) is primarily an internal hazard. However, direct skin contact with C-14 can result in significant beta exposure to the affected location.
- b. C-14 has a radiological half life of 5730 years.
- c. C-14 can become an inhalation hazard. Radioactive carbon dioxide or similar gases may be generated by chemical reactions. Use a fume hood to reduce inhalation risks.
- d. C-14 is not a significant absorption hazard, but like all unsealed materials may be ingested.
- e. Portable survey instruments with thin window GM detectors have a low efficiency for C-14 (approximately 5%), so it is not easily detected by scanning. Direct scanning for contamination must be done slowly (1 to 2 inches per second) in a close proximity (1/2") to the surface being scanned. Contamination surveys should focus on wipe testing with the wipes counted in a liquid scintillation counter.

9.10.9 Other Radioisotopes

The previous information covers the significant hazards associated with some of the commonly used research radioisotopes. For specific information about the hazards of other radioisotopes, contact Radiation Safety and review any vendor supplied information. You should always be aware of the primary hazards (internal, external, or both) and methods of detecting the radioisotopes that you are using.

9.10.10 Sealed Sources

- a. Sealed radioactive sources are primarily an external radiation hazard. However, sealed sources must be used, handled, and stored in such a manner as to prevent the source from becoming an internal (contamination) hazard.
- b. No sealed source may be opened or modified in any way. Sources may not be machined, drilled, cut, or altered.
- c. Avoid handling the active surface of sources. Use tweezers, tongs, or other remote handling devices when working with sources that have the potential to produce significant personnel exposure. However, when using remote handling devices, take precautions not to scratch or damage the surface of the source.
- d. Do not clean sealed sources with abrasives, chemicals, etc. Avoid other potentially damaging conditions such as temperature extremes, mechanical shock, etc.
- e. Sealed sources must be labeled and posted as with any radioactive materials. They are also subject to the same security requirements.
- f. Radioactive sources in electronic devices (i.e. gas chromatographs) must not be removed from the detector cells. Do not open or attempt to clean detector cells in these devices.
- g. Sealed sources shall be leak tested at a frequency specified by the Radiation Safety Office. A leak testing kit will normally be sent to the Authorized User by the Radiation Safety staff at appropriate intervals.

9.11 USEFUL FORMULAS, CONVERSION FACTORS, AND TABLES

Radioactive Decay

This formula may be used to determine the actual activity of a radioactive source by calculating the correction for radioactive decay. Activity can be in units of curies, dpm, etc.

Elapsed time and half life must be in the same units (i.e. hours, days, years).

Decay Formula

$$A = A_0 e^{-0.693 t / T_{1/2}}$$

Where: A = Activity

A_0 = Original Activity

e = base of natural log

t = elapsed time

$T_{1/2}$ = half life

“Rules of Thumb” for Radioactive Decay”

- After 7 half-lives the activity of any radioisotope is reduced to <1% of the original value.
- For radioisotopes with half-lives >6 days, the change in activity in a single 24 hour period is <10%.

Inverse Square Law (Point Source)

The inverse square law may be used to calculate the dose rate at a known distance from a radiation source (point source), when another dose rate and distance are known. For example, if a radiation source is generating a known dose rate at 1 foot, you could use this formula to calculate the dose rate at 3 feet.

$$(I_1) (D_1)^2 = (I_2) (D_2)^2$$

Where: I_1 = dose rate at 1st distance (initial dose rate)
 D_1 = 1st distance (initial)
 I_2 = dose rate at 2nd distance (new dose rate)
 D_2 = 2nd distance (new distance)

Gamma Exposure Rate Calculation

This formula may be used to calculate the dose rate at one foot from a radioactive source, when the activity of the source in curies and the isotope are known. This formula is effective only for gamma radiation dose rates.

$$I_{1ft} = 6CEN$$

Where:

I = the gamma dose rate in Rem/hr at one foot
 C = the source activity in curies
 E = the gamma energy in MeV
 N = the photon yield

- Accuracy is approximately 20% for gamma energies from 0.05 to 3 MeV.
- If N is not given, assume 100% photon yield ($N=1$).
- If more than one photon energy is given, take the sum of each photon energy multiplied by its percentage.

For example: Co-60 emits a 1.173 and a 1.332 MeV gamma, both at a 100% yield. Therefore the EN value of the equation for Co-60 is $(1.173 \times 1) + (1.332 \times 1) = 2.505$

The calculated gamma dose rate at 1 foot from a 100 millicurie Co-60 source would be:

$$I_{1ft} = 6CEN$$
$$I_{1ft} = 6 \times 0.1 \text{ Ci} \times 2.505$$
$$I_{1ft} = 1.503 \text{ Rem/hr} = 1,503 \text{ mrem/hr}$$

Beta Dose Rate Calculation

The dose rate at 1 cm from a beta emitting point source varies only slightly with differences in energy of the beta radiation. However, note that beta radiation is rapidly attenuated in air.

As a “rule of thumb”, the following equation may be used to estimate the 1 cm (contact) dose rate with a beta emitting point source:

$$\text{Beta Dose Rate @ 1cm} = 300 \text{ rad/hr per mCi}$$

The beta dose rate in a solution may be estimated by the following formula:

$$\text{Dose Rate (rad/hr in a solution)} = 2.12 \times E_{\text{avg}} \times C$$

Where E_{avg} = the average beta energy in Mev and C = the concentration in $\mu\text{Ci}/\text{cm}^3$.

This assumes a density of approximately 1 gram/cm³.

The dose rate at the surface of the solution will be approximately ½ of the value in the solution.

Unit Conversion

Based on a given set of units, you may convert to a desired unit by means of a conversion factor. The conversion factors shown here are ratios of two equivalent physical quantities expressed in different units. When expressed as a fraction, the value of a conversion factor is 1.

Conversion factors in the form of fractions may be built as shown in the following example:

1 millicurie (mCi) of a radioisotope has been diluted in a gallon of solution. What is the activity of the solution in $\mu\text{Ci}/\text{ml}$?

Given: 1 mCi/gal, convert to units of $\mu\text{Ci}/\text{ml}$

Units: 1 mCi = 1000 μCi

1 liter = 0.26418 gal

1 liter = 1000 ml

The unit conversion formula may be set up as follows:

$$\frac{1 \text{ mCi}}{1 \text{ gal}} \times \frac{1000 \mu\text{Ci}}{1 \text{ mCi}} \times \frac{0.26418 \text{ gal}}{1 \text{ liter}} \times \frac{1 \text{ liter}}{1000 \text{ ml}} = 0.26418 \mu\text{Ci}/\text{ml}$$

Note that the un-desired units cancel each other out. When only the desired units remain, the conversion has been properly set-up and may be calculated.

Radiological Unit Conversion Factors

Curie units

1 curie (Ci)	1 E +3 millicurie (mCi)
1 curie (Ci)	1 E +6 microcurie (μ Ci)
1 curie (Ci)	1 E +9 nanocurie (nCi)
1 curie (Ci)	1 E +12 picocurie (pCi)

Standard activity units

1 curie (Ci)	3.70 E +10 dps
1 curie (Ci)	2.22 E +12 dpm
1 millicurie (mCi)	2.22 E +9 dpm
1 microcurie (μ Ci)	2.22 E +6 dpm
1 nanocurie (nCi)	2.22 E +3 dpm
1 picocurie (pCi)	2.22 dpm

Rem Units

1 rem	1000 millirem (mrem)
1 rem	1 E +6 microrem (μ rem)
1 millirem (mrem)	1000 microrem (μ rem)

International activity unit

1 Megabecquerel (MBq)	1 E +6 dps
1 becquerel (Bq)	1 dps

Curie to Becquerel conversion

1 curie (Ci)	37 Gigabecquerels (GBq)
1 millicurie (mCi)	37 Megabecquerels (MBq)
1 microcurie (μ Ci)	37 kilobecquerels (kBq)
1 nanocurie (nCi)	37 becquerels (Bq)
1 picocurie (pCi)	37 millibecquerels (mBq)

Becquerel to Curie conversion

1 Terabecquerel (TBq)	27 curies (Ci)
1 Gigabecquerel (GBq)	27 millicuries (mCi)
1 Megabecquerel (MBq)	27 microcuries (μ Ci)
1 kilobecquerel (kBq)	27 nanocuries (nCi)
1 becquerel (Bq)	27 picocuries (pCi)

Rem to Sievert conversion

100 rem	1 sievert (Sv)
1 rem	10 millisievert (mSv)
1 millirem (mrem)	10 microsievert (μ Sv)
1 microrem (μ rem)	10 nanosievert (nSv)

Rad to Gray conversion

100 rad	1 gray (Gy)
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1 rad
1 rad
1 millirad (mrad)
1 microrad (μ rad)

1 centigray (cGy)
10 milligray (mGy)
10 microgray (μ Gy)
10 nanogray (nGy)

10 RADIOACTIVE WASTE HANDLING AND DISPOSAL

10.1 RADIOACTIVE WASTE REDUCTION

10.1.1 Limiting waste production

Whenever practical, limit the production of radioactive waste. Some ways to limit waste production include:

- Training personnel in proper handling and disposal of waste.
- Using the safe work practices and containment devices described in Chapter 9, Laboratory Procedures.
- Avoiding the use or storage of non-essential items or excess packaging materials in locations where they may become contaminated.

10.1.2 Segregation of Radiological and Non-radiological Waste

- Radioactive waste should be limited to non-useable radioactive materials or to materials that are known or likely to be contaminated with radioactive materials.
- Never dispose of non-radioactive waste in radioactive waste containers.
- When appropriate to reduce waste volumes, perform radiological surveys of potentially contaminated dry solid materials to verify that the materials are suitable for non-radioactive disposal or release to unrestricted use.
- Potentially contaminated liquids or dry bulk materials (powders, granulated materials, etc.) may be sampled and analyzed for release as described elsewhere in this chapter.
- Always keep radioactive waste containers closed and properly labeled to reduce the likelihood of spills or improper disposals.

10.1.3 Re-Use and Transfer of Materials

- Properly label and store contaminated items or equipment for re-use.
- When appropriate, decontaminate items instead of disposing of them.
- Items contaminated with short half life isotopes may be packaged, labeled, and stored for radioactive decay. After being allowed to decay for 10 half-lives, the materials may be surveyed or analyzed for release to unrestricted use.

Radioisotopes or contaminated equipment may be transferred from one Authorized User to another instead of becoming waste. Always contact Radiation Safety prior to initiating a transfer.

10.2 DRY SOLID RADIOACTIVE WASTE HANDLING

10.2.1 Segregation of Dry Solid Waste

Segregate dry solid radioactive waste according to following categories:

- a. Long lived waste (half-life >120 days)
- b. Short lived waste (half-life <120 days)
- c. Long-lived mixed waste

- d. Short-lived mixed waste
- e. Sealed radioactive sources

Long-lived waste

Long-lived waste will normally be stored by Radiation Safety pending disposal via a commercial radioactive waste disposal vendor. Please limit the production of this type of waste since commercial disposal is expensive. Long-lived dry waste may be mechanically compacted to achieve volume reduction or incinerated by a licensed vendor. Non-compactable materials and materials that cannot be incinerated should not be put into containers of long-lived dry radioactive waste. Non-compactable and non-incinerable materials include, but are not limited to, metal objects, aerosol cans, and lead shielding materials.

Short-live waste

Radiation Safety will normally hold short-lived waste for radioactive decay. Following decay for a period of 10 radioactive half-lives, the waste will be monitored for the presence of residual radioactivity. If no residual radioactivity is detected the waste will be disposed of as non-radioactive. Containers used to store short-lived waste will be returned to the Principal Investigator after disposal of the contents.

Mixed waste

Mixed waste is any combination of a hazardous waste and a radioactive waste. Handling and disposal of mixed waste is expensive. A hazardous waste is any material listed as hazardous by the EPA (refer to the SDS for this information). Consult with Risk Management Service prior to generating mixed waste. If the estimated cost of disposal of a quantity of long-lived dry mixed waste exceeds the average cost of disposal of a similar quantity of long-lived dry radioactive waste by more than 10%. The Radiation Safety Committee will require the Principal Investigator to arrange for funding to pay for all or part of the disposal costs beyond the average disposal cost for a drum of long-lived dry waste. Short-lived mixed waste will be held for radioactive decay and disposed of as hazardous waste.

Sealed sources

Sealed radioactive sources consist of radioactive material that is permanently bonded or constructed in such a manner as to prevent the release or dispersal of the radioactive material under normal use conditions. Certain instruments and manufactured articles contain sealed radioactive sources such as gas chromatographs and liquid scintillation counters. Contact Radiation Safety for specific instructions regarding disposal of sealed sources or surplus equipment that contains radioactive material. If the estimated cost of disposal of one or more sealed radioactive sources submitted for disposal by an Principal Investigator exceeds the average cost of disposal of a standard size drum of long-lived dry radioactive waste by more than 10%, this will trigger a review by the Radiation

Safety Committee. The RSC may then require the Principal Investigator who generated the waste to arrange for funding to pay for all or part of the disposal costs beyond the average disposal cost for a drum of long-lived dry waste.

The above listed categories should be additionally sub-divided into separate containers when appropriate. For example, different types of hazardous (mixed) waste should not be combined into one container.

Note: Dry radioactive waste materials that are in process will be referred to as dry active waste (DAW). “In process” means that the materials have not officially been classified as radioactive waste for purposes of transportation and final disposal. Treatment options, such as decay in storage, compaction, and incineration, may be used prior to the final classification of this material as low level radioactive waste.

10.2.2 Dry Active Waste (DAW) Containers

- a. The standard container for DAW is a 30-gallon fiber drum with a reinforced metal lock-rim closure lid.
- b. Alternative approved containers include 5-gallon plastic pails with secure screw top lids and 10 to 20 gallon capacity all fiber drums. All fiber drums are preferred for use with long-lived DAW because they are completely incinerable; although they may be used any time, a smaller container is more practical. Smaller containers should be used only in laboratories that generate small quantities of DAW, so that the need for waste pick-ups will not be excessive.
- c. Other special use containers may be approved by the RSO on a case-by-case basis.
- d. Principal Investigators that use more than one of the categories listed in section 10.2.1 must have separate containers for each category.
- e. Procurement of waste containers is the responsibility of the Principal Investigator.
- f. Clearly label the containers and train laboratory personnel to prevent the possibility of mixing the different categories of waste.
- g. All radioactive waste containers must be marked with the standard radiation symbol and the words “Caution, Radioactive Materials.” Labeling should also include the isotope(s) and the estimated maximum activity (mCi) in the container. A minimum of two labels should be used with each label placed on opposite sides of the container.
- h. Empty waste containers should be marked with an “Empty” label in addition to the radioactive materials label.
- i. Temporary collection containers for waste may be used to improve efficiency and reduce the risk of spills. The physical construction of the container must be appropriate for the type of waste. Temporary collection containers should remain closed when not in active use and must not be allowed to overflow. Temporary

collection containers should be labeled in the same manner as other waste containers.

- j. All DAW containers must be lined with a removable polyethylene liner bag (or bags) to achieve a minimum thickness of four mil. Liner bags should not have radioactive materials markings and should not be closed or labeled with radiological warning tape.
- k. Used waste containers that are no longer needed must be turned over to Radiation Safety for disposal or reuse on campus.

10.2.3 Method for Determining the Amount of Radioactivity in DAW

The contents of a typical dry active waste container consist of two primary components: associated waste and known additions. This section describes the methodology for determining the amount of radioactivity that each of these components contributes to the total activity of the container.

Associated Waste

The majority of the volume of most DAW is associated waste. Associated waste consists of general laboratory waste that has been in contact with radioactive materials and is therefore potentially contaminated. Associated waste includes such items as used gloves, paper towels, disposable pipette tips, etc. Associated waste may be subdivided into two types: secondary contact waste and direct contact waste.

- a. **Secondary Contact Waste**

The bulk of associated waste is secondary contact waste. Secondary contact waste consists of materials that have been in limited contact with radioactive materials or have only been in contact with diluted radioactive materials. Based on standard models of transferable contamination, secondary contact waste is calculated to be contaminated to a maximum level of 1% of the original activity with which it was used.

- b. **Direct Contact Waste**

The other component of associated waste is direct contact waste. Direct contact waste is waste that has been in direct contact with un-diluted radioactive materials (stock solutions). Based on standard models of transferable contamination, direct contact waste is calculated to be contaminated to a maximum level of 10% of the original activity with which it was used.

Associated Waste Contamination Factor

Based on these criteria, the activity of the associated waste in a DAW container may be calculated as follows:

$\% \text{ Secondary Contact Waste} \times 1\% = \text{Secondary Contact Waste Contamination Factor (SCWCF)}$

$\% \text{ Direct Contact Waste} \times 10\% = \text{Direct Contact Waste Contamination Factor (DCWCF)}$

$\text{SCWCF} + \text{DCWCF} = \text{Associated Waste Contamination Factor (AWCF)}$

Based on a standard model of 80% secondary contact waste and 20% direct contact waste, the Associated Waste Contamination Factor for use at the university is 3%. Therefore, 3% of the total radioactivity that was used during the period from the initial date the container was put in service to the date of closure is the calculated activity of the associated waste in the container.

In the event that a laboratory's associated waste does not meet this standard model, Radiation Safety will develop a revised Associated Waste Contamination Factor (AWCF) based on input from laboratory personnel regarding the characteristics of waste generated.

Known Additions

When radioactive materials of a known isotope and activity are added to the container, these materials should be listed separately from associated waste and added to the total activity of the container. Known additions include any media suitable for the dry waste container that contains measured or calculated quantities of radioisotopes. If there are no known additions to a waste container the total activity of the contents will be determined exclusively by use of the associated waste contamination factor.

10.2.4 Use of the DAW Log

Initiate a DAW Log when a dry active waste container is put into service. A DAW Log may be printed and attached to the container with the start date and isotope(s) listed on the form. Known additions and the Lot/Batch numbers of completely used radioisotope orders may be written on the form in the spaces provided as waste is being added to the container. The DAW Log may also be maintained exclusively in an electronic format as long as the container is labeled with the standard radiation markings, the isotope(s), and the estimated total activity that the container is likely to hold.

Use separate containers and log sheets for each category of waste, as described in section 10.2.1 of this chapter.

If more than one container is in use at any one time, special care must be taken not to mix up the data from one log sheet to another.

When a DAW container is full or when you are ready to have the container picked up by Radiation Safety, the following tasks must be performed:

- a. The final copy of the DAW Log should be completed. A copy of the log must be submitted to Radiation Safety. A signed copy is required for labeling the container.
- b. Record the required data in support of the associated waste calculation to account for non-specific waste in the container.
- c. The total amount of radioactivity in the container is the total of the associated waste calculation and the known additions.
- d. Perform a contamination survey of the exterior of each container and record the results in the space provided on the form. Contamination levels on containers must not exceed 1000 dpm/100 cm². Contaminated containers should be decontaminated and resurveyed as described in Chapter 9, Laboratory Procedures.
- e. Perform a radiation dose rate survey of the exterior surface of the waste container and record the results in the space provided on the form. If the contact dose rate exceeds 0.5 mrem/hr, notify Radiation Safety of the dose rate on the container when you request a pick-up. The Radiation Safety staff will verify the radiation dose rates and provide appropriate labeling for the container at the time of pick-up.
- f. Sign and date the DAW log. Waste container paperwork should only be completed by, or under the supervision of, a Principal Investigator or/and an Authorized User.
- g. Attach the completed DAW Log to the container and notify Radiation Safety that the container is ready for pick-up.

10.3 ANIMAL CARCASSES AND BIOHAZARD WASTE

- a. Notify Radiation Safety prior to initiating any new projects resulting in the generation of animal carcasses or biohazardous waste contaminated with radioactive materials.
- b. Animal carcasses and biohazardous waste may be disposed of as if it were not radioactive **IF** the disposal is documented and approved by Radiation Safety, the disposal method is appropriate for the physical and biohazardous properties of the material, and the material consists of one or more of the following:
 - Animal tissue that does not contain more than 0.05 μ Ci of H-3 or C-14 per gram.
 - Waste that contains radioisotopes in concentrations that do not exceed the appropriate effluent limit specified in 10 CFR 20 Appendix B, Table 2.
 - Waste that contains short lived radioisotopes that has been held for radioactive decay for a minimum duration of 10 half lives and when monitored with an appropriate portable instrument shows no detectable activity.
- c. Animal carcasses and biohazardous waste must be properly labeled and safely stored pending disposal.
- d. Radiation Safety will NOT pick up any radioactive biohazardous waste for storage or disposal unless the Principal Investigator has verified that the waste has been deactivated, decontaminated, or sterilized.

- e. Waste that has been deactivated, decontaminated, or sterilized should not be labeled as biohazardous. Radiation Safety will not pick up radioactive waste in bags or containers with biohazard labels for disposal.

Note: Refer to the University's Biosafety Manual for specific information about biohazardous waste.

10.4 LIQUID RADIOACTIVE WASTE HANDLING

10.4.1 Segregation of Liquid Waste

Segregate liquid radioactive waste according to the following categories

- a. Long lived waste (half life >120 days)
- b. Short lived waste (half life <120 days)
- c. Long lived mixed waste
- d. Short lived mixed waste
- e. Non-biodegradable liquid scintillation counting fluid containing exclusively H-3 and/or C-14 in concentrations not to exceed 0.05 $\mu\text{Ci}/\text{gram}$

Note: For best results when performing radioactive analysis of liquids, use separate containers for each radioisotope.

The production of long-lived liquid mixed waste should be kept to a minimum. If the estimated cost of disposal of a quantity of long lived liquid mixed waste exceeds the average cost of disposal of a standard size drum of long-lived dry radioactive waste by more than 10%, this will trigger a review by the Radiation Safety Committee. The RSC may then require the Principal Investigator who generated the waste to arrange for funding to pay for all or part of the disposal costs beyond the average disposal cost for a drum of long-lived dry waste.

Short lived liquid mixed waste will be held for radioactive decay by Radiation Safety and disposed of as hazardous waste.

The Radiation Safety staff perform disposal of waste by radioactive decay. Although some radioactive decay does occur while waste is being accumulated in authorized use locations, the tracking, storage, monitoring, and disposal of waste via the radioactive decay process is performed in a designated facility by Radiation Safety.

Sewer disposal involves the discharge of carefully measured and tracked quantities of radioactive liquids into the sanitary sewer system. These disposals may only be performed in accordance with specific regulatory limits on both the concentration of radioactivity in a liquid and the total amount of radioactivity that the University may release on a monthly and annual basis. Due to the large volume of water in a municipal sanitary sewerage system, these disposals become diluted and therefore do not contribute significantly to environmental radioactivity levels. Short lived radioisotopes are typically held for radioactive decay prior to disposal. Specific approval for sewer disposal may be granted to Principal Investigator by the RSC on an individual basis.

Adding or terminating sewer disposal approval is handled via the Radioactive Materials Permit amendment process.

Radioactive waste disposal by off-site shipment to an approved waste disposal vendor is performed exclusively at the University by the Radiation Safety staff. Such shipments are strictly regulated and expensive operations.

10.4.2 Disposal of Used Liquid Scintillation counting fluid

- a. LSC fluid should be verified biodegradable by checking the manufacturer's specifications prior to purchase.
- b. Biodegradable liquid scintillation fluid should be consolidated into a liquid waste carboy and segregated by isotope.
- c. Non-biodegradable liquid scintillation fluid or any scintillation fluid that contains hazardous chemicals must be controlled as hazardous or mixed waste. Refer to Safety Data Sheets (SDS) to determine if the EPA lists a material as hazardous. However, hazardous wastes that contain radioactive materials in concentrations below the effluent release limits of 10 CFR 20 will be considered hazardous waste and not mixed (radioactive) waste. Consolidate these liquids into a separate carboy for analysis by Radiation Safety prior to disposal.
- d. Non-biodegradable liquid scintillation fluid or any scintillation fluid that contains hazardous chemicals containing exclusively H-3 or C-14 in concentrations below 0.05 μCi per ml will be considered hazardous waste and not mixed (radioactive) waste. Consolidate these liquids into a separate carboy for analysis by Radiation Safety prior to disposal.
- e. If you are counting wipe test samples for surface contamination measurements, you may dispose of any wipe samples, the associated scintillation fluid, and the vials as non-radioactive IF the wipe test results are <200 dpm.
- f. If any individual sample counting results are less than two standard deviations above the counting instrument's background, the scintillation fluid and sample vial may be disposed of as if it is not radioactive.

Example: A 1 minute background results in 25 counts. This equals a background count rate of 25 counts per minute (cpm). The square root of 25 cpm is 5, and $5 \times 2 = 10$. Therefore, if a sample does not exceed a gross result of 35 cpm, or a net result of 10 cpm (gross cpm – background cpm = net cpm), the sample is considered non-radioactive. Both the vial and its contents may be disposed of without regard to radiological concerns.

- g. If the individual sample results are greater than two standard deviations above background (excluding wipe tests), the contents of the vials should be poured into an appropriate waste carboy. Segregate waste by half-life and hazardous characteristics as described in section 10.4.1.

- h. Empty scintillation vials that were used for analysis of H-3 or C-14 may be disposed of in regular (non-radioactive) trash. Empty scintillation vials that were used for analysis of other isotopes may be disposed of in regular (non-radioactive) trash, IF the count rate of the samples did not exceed 500 cpm.
- i. If disposal of liquid scintillation fluid and vials will not occur promptly after counting, segregate and label the vials while disposal is pending. Used vials of liquid with counting results < 2 standard deviations above background should be separated from radioactive materials while disposal is pending. Used vials of liquids pending packaging for disposal as radioactive materials must be labeled, or kept in suitable containers (i.e. plastic bins) labeled with the standard radiation symbol, the words “Caution, Radioactive Materials”, and the isotope, amount (μCi or mCi), and date. Storage of excessive quantities of used vials is not an acceptable practice.

10.4.3 Liquid Radioactive Waste Containers

- a. The standard approved container for liquid radioactive waste is a 2.5-gallon polyethylene jerrican. Other containers may be approved by the RSO/RSC on a case by case basis.
- b. Principal Investigator that are approved for use of more than one of the categories listed in section 10.4.1 must have separate containers for each category.
- c. Clearly label the containers and train laboratory personnel to prevent the possibility of mixing the different categories of waste.
- d. Radioactive waste containers must be marked with the standard radiation symbol and the words “Caution, Radioactive Materials.” Labeling should also include the isotope(s) and the estimated maximum activity (mCi). A minimum of two labels should be used with each label placed on opposite sides of the container.
- e. Empty waste containers should be marked with an “Empty” label in addition to the radioactive materials label.
- f. Temporary collection containers for waste may be used to improve efficiency and reduce the risk of spills. The physical construction of the container must be appropriate for the type of waste. Temporary collection containers should remain closed when not in active use and must not be allowed to overflow. Temporary collection containers should be labeled in the same manner as other waste containers.
- g. Used waste containers that are no longer needed must be turned over to Radiation Safety for disposal or reuse on campus.

10.5 SAMPLING, ANALYSIS, EVALUATION AND DISPOSAL OF LIQUIDS

When a liquid waste container is full, or if disposal of the contents is desired, collect and analyze a representative sample of the contents of the container.

The method of analysis and documentation will be one of the following three options:

- If the liquid contains exclusively H-3, C-14, P-32, P-33, and/or S-35 in concentrations likely to be less than the ALARA action levels of Table 5.A, the liquid may be evaluated for release. Perform and document an analysis and evaluation for release in accordance with section 10.5.3, *Evaluation of Liquids for Release*.
- If the liquid does not meet the criteria described above, perform and document analysis for pick-up by Radiation Safety in accordance with section 10.5.4, *Liquid Radioactivity Analysis for a Waste Pick-Up*.
- If your Radioactive Materials Permit (license) authorizes sewer disposal, perform and document analysis in accordance with section 10.5.5, *Sewer Disposal Permits*.

10.5.1 Counting Instrument Consideration for Liquid analysis

- Instruments used for liquid waste disposal evaluations should have performance checks and routine maintenance performed as recommended by the manufacturer. Instruments that are not in good working order or properly maintained must not be used to evaluate samples for release to unrestricted areas. For assistance with instrument performance checks, contact Radiation Safety. Instrument repair needs should be directed to qualified vendors, or the instrument manufacturer.
- The counting equipment used must be capable of meeting the desired release limit. Therefore, the counters minimum detectable activity (MDA) value must be less than the release limit. In some cases, counting times may have to be extended to enable an MDA value to be reached. Calculate the MDA by use of the formula:

$$\text{MDA in } \mu\text{Ci/ml} = \frac{2.71 + 4.66 \sqrt{\text{bkg cpm}}}{(\text{efficiency}) (\text{count time}) (2.22 \text{ E } 6) (\text{sample vol.})}$$

Example: A 1 minute counting time, 50 cpm background (bkg), LSC efficiency for H-3 of 0.35, and sample volume of 2 milliliters would give a MDA of 2.29 E-5 $\mu\text{Ci/ml}$. Therefore, it would be appropriate to count a 2 ml sample for 1 minute for H-3 at this background level (or less) because the ALARA action level for release of H-3 is 2 E-4 $\mu\text{Ci/ml}$. If the calculated MDA is less than the action level, the variable parameters of counting time and background are suitable for the release analysis.

- If a counting instrument's background is high (i.e. >50 cpm), the sample counting time may have to be increased in accordance with an MDA calculation. **A high background should be investigated, possible causes include contamination of the**

counting instrument or the placement of radiation sources (waste containers, stored isotopes, etc.) nearby.

- d. Liquids that contain significant quantities of known quenching agents that are likely to contain radioactive material should be considered radioactive waste and not evaluated for release. Analyze samples of these liquids for pick-up by Radiation Safety as described in section 10.5.4. Coloring agents, non-homogenous samples, and certain chemicals will interfere with liquid scintillation counting. To ensure accurate counting, samples should have visible clarity (lack of coloration) and homogeneity.

10.5.2 Procedure for sampling and analysis of liquids

- a. Sampling must be representative. Liquids should be uniformly mixed (shaken, stirred, etc.) prior to sampling.
- b. Collect and pipette a sample of the liquid waste into a sample-counting vial. The standard sample volume to use is 1 milliliter. When performing sample analysis for release evaluations the sample volume must be adequate to ensure that the required minimum detectable activity (see section 10.5.1) is met.
- c. Add the appropriate amount of scintillation fluid for use with your liquid scintillation-counting instrument to the vial (i.e. 7, 10, or 20 ml of scintillation fluid).
- d. If you are using a gamma counter, follow the standard counting protocols for that instrument.
- e. Set-up the instrument to count in the spectrum of the isotope known or suspected to be present. Multiple isotopes must have distinct energy spectrums to permit differentiation. Segregate liquids by radioisotope to facilitate analysis.
- f. If a liquid waste carboy contains multiple isotopes that are not easily differentiated by analysis, the sample should be analyzed by full spectrum counting. The analysis sheet should list all the isotopes in the container and the total activity.
- g. Count a background sample and the prepared sample for the appropriate minimum counting time. A minimum counting time of 1 minute should be used for radioactivity analysis or sewer disposal. Liquid release evaluations require longer counting times, see section 10.5.3 for details.

10.5.3 Evaluation of liquids for release

If you generate liquids that contain very low concentrations of certain radioisotopes, you may evaluate these liquids for release in accordance with the regulations for liquid effluents. Each individual radioisotope has its own release limit. The action levels provided only include those radioisotopes commonly used on campus that have release limits easily detected by liquid scintillation counting.

Note: The ALARA action levels for release of liquids represent 20% of the liquid effluent release values permitted by the Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 20, Appendix B, Table 2, Column 2. These values are based solely on the concentration ($\mu\text{Ci/ml}$) of radioactivity in the liquid. This very low level of radioactivity is considered safe for release as a liquid effluent. NRC models

show that if a person were continually exposed to this level of radioactivity their annual exposure would only increase by 10mrem in an entire year.

Appropriate records must be kept to provide verification that the releases are performed in accordance with the regulations. **If you have any doubt about whether or not a liquid is suitable for release, you should consider the liquid to be radioactive, perform analysis as described in section 10.5.4, and arrange for a pick-up by Radiation Safety.** In addition, if Radiation Safety determines that a Principal Investigator is not performing liquid releases properly, the option to use this disposal method may be revoked at the discretion of the RSO.

**Table 5.A
Liquid Release ALARA Action Levels**

Isotope	Liquid Release ALARA Action Level (µCi/ml)	Liquid Release ALARA Action Level (dpm/ml)	Counting Method	Standard Counting Efficiency	Liquid Release ALARA Action Level (cpm/ml)
H-3	2.00E-4	444 dpm/ml	LSC	0.35	155 cpm/ml
C-14	6.00E-6	13 dpm/ml	LSC	0.85	11 cpm/ml
S-35	2.00E-5	44 dpm/ml	LSC	0.85	37 cpm/ml
P-33	1.60E-5	35 dpm/ml	LSC	0.85	30 cpm/ml
P-32	1.80E-6	4 dpm/ml	LSC	0.98	4 cpm/ml

Table 5.A. provides a list of some typically used isotopes and their respective liquid release ALARA action levels in units of µCi/ml and in dpm/ml. These values should be used to evaluate the proper disposal route for liquid waste.

The isotopes I-125 and I-131 are not suitable for release in this manner, due to the very low limits for release of these isotopes. Release limits for other radioisotopes not listed in Table 10.5.3 may only be approved by the RSO on a case by case basis.

Liquid Release Evaluation Procedure

- a. Collect a representative sample of the liquid waste in accordance with section 10.5.2. The sample volume must be adequate to ensure that the required minimum detectable activity is met, as shown in the table below.
- b. Add the appropriate amount of scintillation fluid for use with your counting instrument to the vial containing the liquid waste sample.
- c. Analyze a background sample and the prepared liquid waste sample for a counting time that is adequate to meet the required minimum detectable activity. Examples of

suitable sample volumes, instrument background levels, and minimum counting times are specified in the following table.

Radioisotope	Sample Volume	Maximum Background	Minimum Counting Time
H-3, S-35, P-33	1 ml	50 cpm	5 minutes
H-3, S-35, P-33	2 ml	50 cpm	1 minute
C-14	1 ml	50 cpm	20 minutes
C-14	2 ml	50 cpm	10 minutes
P-32	2 ml	75 cpm	30 minutes
P-32	3 ml	75 cpm	15 minutes

d. Calculate the MDA by use of the formula:

$$\text{MDA in } \mu\text{Ci/ml} = \frac{2.71 + 4.66 \sqrt{\text{bkg cpm} \times \text{count time}}}{(\text{efficiency}) (\text{count time}) (2.22 \text{ E } 6) (\text{sample vol.})}$$

One of the following 2 options is possible:

- If the sample results are less than the ALARA action levels for release of liquids, the liquid in the container is suitable for release. The liquid may be disposed of as appropriate for its physical and chemical properties. This will typically be sink disposal if the liquid is biodegradable, aqueous, and non-hazardous. If the liquid has hazardous or other constituents that make it inappropriate for sink disposal, it may be disposed of via the normal (non-radioactive) disposal route for that liquid.
 - If the sample results exceed the ALARA action levels for release, the liquid is NOT suitable for release. Label accordingly and store the liquid until a pick-up is scheduled with Radiation Safety. See section 10.6 for waste pick-up information.
- e. If the liquid is not suitable for release, the following actions are required:
- Perform a contamination survey of the exterior of the container and record the results. Contamination levels on containers must not exceed 1000 dpm/100 cm². Contaminated containers should be decontaminated and resurveyed as described in Chapter 9, *Laboratory Procedures*.
 - Perform a radiation dose rate survey of the exterior surface of the waste container and record the results. If the contact dose rate exceeds 0.5 mrem/hr, notify Radiation Safety of the dose rate on the container when you request a pick-up. The Radiation Safety staff will verify the radiation dose rates and provide appropriate labeling for the container at the time of pick-up.
- f. Release evaluation paperwork should only be completed by, or under the supervision of, a Principal Investigator or Authorized user.

- g. Notify Radiation Safety when a container is ready for pick-up and attach the required paperwork.
- h. If disposal is performed by release, you must provide a copy of the completed Liquid Release Evaluation to Radiation Safety.

10.5.4 Sewer Disposal Permits

- a. Sewer disposal permits allow the controlled release of low levels of liquid radioactive materials in concentrations that are higher than the limits of Table 10.5.3. Sewer disposal permits will be limited to Principal Investigator who show the need to conduct these releases.
- b. Sewer discharge is only allowed into public sanitary sewerage systems. Private systems, septic tanks, or leach fields shall not be used for disposal of radioactivity at these levels.
- c. No radioactive materials may be disposed of by sewer disposal without specific approval in the Radioactive Materials Permit of the Principal Investigator. When such disposal is approved, records must be maintained listing the isotope, amount, and date of disposal.
- d. When approved for a sewer disposal permit, sewer disposal records must be submitted to Radiation Safety every month. Since sewer disposals are tracked on a monthly basis, sewer disposal records are required to be submitted regardless of the amount of disposal that occurred. Even if the sewer disposal value is zero, monthly reporting is required.
- e. Approved concentrations for disposal will generally not exceed 0.05 microcuries per milliliter. The standard activity limits are as follows: **500 μCi for H-3, 100 μCi for C-14, and 100 μCi for all other isotopes combined.** Sewer disposal of radioactive iodine (I-125/131) or other isotopes in toxicity groups 1 or 2 (see Chapter 3, Table 3.A.) is generally prohibited. In the event that sewer disposal of a non-standard isotope or quantity is requested the RSO and RSC will evaluate the request on a case by case basis.
- f. Liquids pending disposal in accordance with a sewer disposal permit should be consolidated in a standard liquid waste container (carboy) or equivalent.

Sewer Disposal Procedure

- a. The Sewer Disposal Log should be completed.
- b. Collect a representative 1 ml sample of the liquid as described in section 10.5.2.
- c. Count a background sample and the prepared liquid waste sample for a minimum of 1 minute in an appropriate counter.
- d. Enter the required data on the Sewer Disposal Log.
- e. If the sample results exceed the limits in your sewer discharge permit (either the $\mu\text{Ci}/\text{ml}$ or total μCi), do not proceed with sewer discharge. Delete the entry from your

Sewer Disposal Log and use the Liquid Radioactivity Analysis form to document the analysis.

- f. When all sewer disposals for the month are completed, a signed copy is required as a record of disposal.
- g. Send the completed Sewer Disposal Log to Radiation Safety in conjunction with your monthly radiological survey. If no sewer disposal is performed for the current month this should be noted.
- h. Sewer disposal shall be performed only at designated locations in posted Radioactive Materials Areas.
- i. Discharge liquid waste slowly to minimize splashing with water running to be sure that the material moves out of the sink and into the sewer system.
- j. Survey the sink and surrounding work surfaces to confirm that no residual material or contamination remains in the sink or on the work surfaces. Decontaminate as appropriate.

10.6 WASTE PICK-UPS

Used radioactive materials collected from University laboratories are taken to the radioactive material storage bunker. Channels of disposal include storage for decay and compaction for shipment to a commercial disposal site.

Full radioactive waste containers are not allowed to accumulate in a laboratory. Contact Radiation Safety and schedule waste pick-ups to prevent accumulation of full containers in work locations.

10.6.1 Preparing for Pick-up

- Verify that each individual container has a Radiation waste log attached to it.
- Make sure that the paperwork contains all required information. Complete each section of the forms.
- Perform a contamination survey of the exterior of each container. Contamination levels on containers must not exceed 1000 dpm/100 cm². Contaminated containers should be decontaminated and resurveyed as described in Chapter 9, Laboratory Procedures.
- Perform a radiation dose rate survey of the exterior surface of the waste container. If the contact dose rate exceeds 0.5 mrem/hr, notify Radiation Safety of the dose rate on the container when you request a pick-up. The Radiation Safety staff will verify the radiation dose rates and provide appropriate labeling for the container at the time of pick-up.
- Sign and date the forms. Waste container paperwork should only be completed by, or under the supervision of, a Principal Investigator or an Authorized User.

10.6.2 Scheduling and Performance of Waste Pick-Ups

In order to have radioactive waste picked up from your accumulation area, please submit a Hazardous Materials Pickup Request using the RMS website. The form can be used to pick up a single container or multiple containers of waste. Please complete the electronic form in its entirety and outline the contents of each container as completely as possible. Containers without proper labeling will not be picked up.

11 RADIATION PRODUCING EQUIPMENT

11.1 PURPOSE AND SCOPE

The purpose of this chapter is to provide instruction for the use and control of radiation producing equipment at University of North Texas. The information in this chapter is based on the requirements set forth by federal agencies and the State of Texas Department of State Health Services/Radiation Control. This chapter applies to all personnel working under the UNT Radiation Safety Program.

Radiation producing equipment is defined as any equipment that produces or contains sources of ionizing radiation. This equipment may be used in the disciplines of the healing arts (i.e., medicine, osteopathy, dental or veterinary) or non-healing arts (industry, education or research). In most cases, equipment covered under this procedure contains a sealed source of radiation or an x-ray producing vacuum tube or housing. Industrial products and manufactured equipment containing exclusively exempt quantities of radioactive material are excluded from the requirements of this chapter.

11.2 PRECAUTIONS AND LIMITATIONS

- Radiation shall not be applied to human beings except as prescribed by persons licensed to practice in the healing arts.
- The operation of any radiation machine on University campus is prohibited unless the equipment is registered with the State of Texas Department of State Health Services/Radiation Control.
- No routine operations should be conducted that would require an individual to expose any part of their body to the primary beam of a radiographic device, unless that individual is a patient in a healing arts procedure.
- Unqualified personnel must not attempt to remove sealed sources from instruments, equipment, or housings. This task must be performed by authorized personnel or qualified vendors. Contact Radiation Safety for specific information.
- No one is permitted to open or breach the containment of any radioactive sealed source contained in radiation producing equipment. Potentially serious radiological consequences could occur.
- Non-radiological safety hazards (mechanical, electrical, etc.) may be associated with radiation producing equipment and are beyond the scope of this chapter.

11.3 GENERAL INFORMATION

11.3.1 X-ray Generating Equipment

Like gamma radiation, x-rays are a type of ionizing electromagnetic radiation. X-rays are produced when charged particles, usually electrons, are accelerated in a vacuum by an electrical voltage. The electrons interact with a target material, resulting in a release of energy from the target in the form of x-rays. Examples of this equipment include x-ray machines, fluoroscopes,

and equipment that may produce x-rays as an unwanted by-product, such as electron microscopes.

When x-rays interact with any material, some x-rays may pass completely through the material, some may depart all of their energy within the material, and some will scatter. The scattering effect occurs when x-rays “bounce off” surfaces and results in the majority of exposure to personnel operating radiographic equipment.

11.3.2 Sealed Sources Irradiators

Sealed source irradiators typically consist of a shielded radiation source that can be mechanically activated (unshielded) to cause a target to be exposed. When in the shielded mode (off position) radiation levels are usually minimal. The type and energy of radiation emitted is dependent on the isotope used as a source. Gamma emitting isotopes with relatively long half lives are commonly used.

11.3.3 Radiation Safety Considerations

Radiation safety measures for radiation producing equipment include the following:

- access controls
- training of personnel
- appropriate use of time, distance, and shielding (see Chapter 9, *Laboratory Procedures*)
- radiological postings
- warning indicator lights that alert personnel when equipment is operational
- mechanical interlocks on doors and access panels to prevent x-ray production during personnel access
- periodic testing and maintenance to ensure that equipment is operating properly

11.4 REGISTRATION OF RADIATION PRODUCING EQUIPMENT

All instrumentation or equipment capable of producing ionizing radiation must be registered with Radiation Safety. Registration is made by completing the registration form (or an approved equivalent). The form should be sent to Radiation Safety a minimum of 10 days before the instrument is placed in service at UNT. All information on the registration form should be complete and accurate. The individual primarily responsible for use and/or ownership of the equipment will be considered the registered user.

Radiation producing equipment that contains radioactive sources is subject to the authorization, procurement, control, and disposal requirements for radioactive materials as described in this Radiation Safety Manual. However, radiographic equipment is not subject to the radioactive materials requirements of this manual.

11.5 TRAINING

Radiation Safety can provide training in the fundamentals of radiation safety and basic x-ray safety. Training in proper operation and safety for specific equipment must be performed or supplied by the registered user/primary operator. The registered user must maintain documentation adequate to assure that only individuals instructed in safe operating procedures operate all radiation machines and associated equipment under the control of the registered user.

11.5.1 Training of Operators who Administer X-ray in the Healing Arts

The registered user must ensure that persons operating his/her radiation machine and associated equipment receive, at a minimum, six hours of instruction. The following subject categories are to be covered:

- a. Protection Against Radiation
 - Protective Clothing
 - Patient Holding
 - Time, Distance, Shielding
 - Radiation Protection Standards
- b. Dark Room Techniques
 - Developing Chemicals
 - Film Protection
 - Cassettes
 - Screens
- c. Patient Protection
 - Beam Limitation
 - Setting Up Techniques
 - Biological Effects of Radiation
- d. Machine Safety
 - Machine Functions
 - Safety Procedure
 - Recognizing Problems

11.5.2 Training Operators who work with Radiation producing machines in all other Application (Non-Healing Arts)

The registered user must ensure that persons operating his/her radiation machine and associated equipment receive, at a minimum, two hours of instruction in the following six subject categories:

- a. Fundamentals of Radiation Safety
 - Characteristics of radiation

- Units of radiation measurement
 - Significance of radiation dose and exposure (radiation protection standards and biological effects)
 - Sources and levels of radiation
 - Methods of controlling radiation dose (time, distance, and shielding)
- b. Radiation Detection Instrumentation to be Used
- Use of radiation survey instruments (operation, calibration, limitations)
 - Use of personnel monitoring equipment (dosimetry)
- c. Radiographic Equipment to be Used
- Remote handling equipment
 - Radiographic exposure devices and sealed sources
 - Operation and control of x-ray equipment
- d. Pertinent Federal and State Regulations
- e. The Registered Users Written Operating and Emergency Procedures

11.6 PERSONNEL EXPOSURE LIMITS

The register user must comply with the requirements of Chapter 2, *Radiation Exposure Limits*. In addition, users of radiographic equipment must comply with the following exposure limits.

**Table 11.A.
Radiographic Equipment Quarterly Exposure Limits**

Location	mrem/quarter Limit
Whole body; head and trunk; active blood forming organs; lens of eyes; or gonads	1250 mrem
Hands and forearms; feet and ankles	18,750 mrem
Skin of the whole body	7500 mrem

- Individuals under 18 years of age shall be limited to 10% of the limits in Table 11.A.
- Radiation exposure to declared pregnant women shall comply with the requirements of Chapter 2, Radiation Exposure Limits.
- Patients undergoing procedures in the healing arts are exempt from these exposure limits.
- Radiation exposure rates in unrestricted areas shall be such that, if an individual were continuously present in the area, the exposure to that individual would not exceed 2mrem in any one hour or 100 mrem in any 7 consecutive days.

11.6.1 Personnel Monitoring

Radiation monitoring dosimetry is required for all individuals:

- likely to receive 25% of the limits specified in Table 11.A.
- entering high radiation areas
- under 18 years of age

When using protective aprons, personnel dosimetry shall be worn outside the apron at collar level.

For additional information about procurement and control of personnel dosimetry, see Chapter 9, *Laboratory Procedures*.

11.7 SAFETY REQUIREMENTS FOR RADIATION PRODUCING EQUIPMENT

- Facilities considerations, including design requirements must comply with the TDSHS Laws and Rules - X-Ray Machines and Services and must ensure that the radiation exposure limits for unrestricted areas described in section 6 of this chapter are met. Where appropriate, a qualified expert should be consulted in the design of new facilities or in the modification of existing facilities.
- Qualified personnel must perform installation, calibration, maintenance, repairs, testing, and radiological monitoring. Vendors and associated personnel responsible for these duties must keep documentation adequate to show evidence of compliance with the rules and regulations.
- Radiation producing equipment shall be tested prior to initial use, after the performance of any modifications, maintenance, or repairs with the potential to affect safety, at any time an abnormal condition is noted, and in accordance with regulatory requirements.
- Equipment warning labels and labels that contain information related to the make, model, or manufacturer of radiation producing equipment are to be maintained in a legible condition. Refer to Chapter 7, Radiological Postings, for information regarding radiation warning signs, labels, and postings.
- The registered user is responsible for maintaining appropriate documentation in support of regulatory compliance.
- Radiation producing equipment capable of generating a high radiation area (100 mrem/hr @ 30 cm from the source of radiation) must be kept locked or otherwise controlled to prevent unauthorized access.
- The useful beam of radiographic equipment shall be limited to the smallest area practicable, consistent with the objectives of the radiological examination or treatment.
- All interlocks, shutters, dead-man switches, beam limiting devices, collimating devices, filters, primary and secondary barriers, and fail-safe devices shall be used or installed in accordance with regulatory requirements, must be properly maintained,

and cannot be modified in any way that would compromise their safety or effectiveness.

- i. X-ray films, intensifying screens, and other image recording devices should be as sensitive as is consistent with the requirements of the examination or procedure being conducted.
- j. Particular care should be taken to align the x-ray beam to ensure that only the target area is irradiated and to reduce the need for performing more procedures than necessary.
- k. Only persons whose presence is necessary may be allowed in radiographic areas during exposure.
- l. Protective clothing, in the form of gloves and aprons with a shielding ability of at least 0.25mm lead equivalent, should be provided and worn in radiographic areas during exposure, except when individuals are entirely behind a protective barrier.
- m. Radiographic equipment, as well as image processing and film devices, should be maintained under a quality control program adequate to minimize the unproductive use of radiation.
- n. Equipment that produces x-rays as an unwanted by-product, such as electron microscopes and cathode-ray tubes, is not allowed to exceed a radiation dose rate of 0.5 mr/hr at a distance of 5 centimeters (2 inches) from any readily accessible point.

11.8 TRANSFER AND DISPOSAL OF RADIATION PRODUCING EQUIPMENT

11.8.1 Transfers of Radiographic Equipment

Radiation Safety should be notified prior to the transfer of radiographic equipment from one registered user to another or to an off-campus location. The registered user on file with Radiation Safety is responsible for initiating this notification. Appropriate paperwork will need to be filed with the TDSHS reflect the change in registration for the radiographic equipment.

11.8.2 Disposal of Radiographic Equipment

Radiographic equipment that is to be disposed of (not transferred) must be rendered in-operable to ensure that it will not be a danger to unqualified personnel. Contact Radiation Safety for guidance in proper disposal of this equipment.

11.8.3 Transfer and Disposal of Equipment Containing Radiation Sources

The requirements for transfer of radioactive materials are described in Chapter 5, *Procurement and Transfer of Radioactive Materials*. For disposal of radiation sources contact the Radiation Safety staff and refer to Chapter 10, *Radioactive Waste Handling and Disposal*.