University of Texas at Dallas
Radiation Safety Manual

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INTRODUCTION

The procedures and policies set forth herein are intended to provide for the control of radioactive materials and radiation producing devices and to ensure strict compliance with the **Texas Regulations for the Control of Radiation** (TRCR) at The University of Texas at Dallas. These regulations, found at 25 TAC §289.201-§289.301, govern the acquisition, transportation, handling, use, storage, and disposal of radioactive materials as well as the use of radiation producing devices. Copies of the TRCR are available in the Radiation Safety Office and the Office of Environmental, Health and Safety. University employees concerned with the purchasing, receiving, handling, use, storage, and disposal of radioactive materials will comply with the procedures in this manual. The Radiation Safety Officer (RSO) is the person designated by the President as responsible for the radiation safety program and maintenance of the license and associated records, and is the primary contact with the Texas Department of Health in administering the license. The RSO has the authority to set radiation safety policy, suspend activities deemed unsafe, and require and direct remedial action where necessary.

EMERGENCY TELEPHONE NUMBERS

	Office Hours 8 a.m.-5 p.m.	Non-office Hours
Radiation Safety Office West Tech Building	4111	2331
Radiation Safety Officer Kathy White	6111	2331
University Police	2331	2331

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

After 5:00 p.m., the University Police will assist in contacting the Radiation Safety Officer.

SECTION I: GENERAL INFORMATION

A. RADIATION SAFETY OFFICER'S RESPONSIBILITY

The Radiation Safety Officer is responsible for:

1. Reviewing all proposals for use of radioactive material.
2. Preparing license applications, amendment applications, and required reports as well as acting as the contact point for all correspondence with State and Federal Radiation Health Agencies.
3. Prescribing special conditions and requirements as may be necessary for safe and proper use of all radiation sources.
4. Preparing and disseminating information on Radiation Safety for the use of and guidance of staff and students.
5. Providing personnel monitoring services including the reviewing and recording of commercially processed dosimeter reports.
6. Performing or arranging for bioassays in accordance with the conditions of the University's license, or when ingestion of radioactive materials is suspected.
7. Ensuring that radiation safety guidelines and requirements are followed in the laboratories utilizing radioisotopes or ionizing radiation.
8. Investigating unusual radiation exposures, incidents, and accidents and reporting corrective action to the appropriate dean.
9. Supervising and coordinating the waste disposal program, including the keeping of waste storage and disposal records.
10. Maintaining records of the receipt, use, storage, and disposal of radioactive material.
11. Performing radiation surveys and monitoring all facilities in which radioactive materials are used, or where radiation-producing equipment resides. Surveys shall include checks on the investigator's contamination surveys.
12. Performing or arranging for six (6) month leak tests on all registered sealed-sources.
13. Acting as consultant in the design of all new facilities using radioactive material, or constructed for the purpose of providing protection against radiation exposure.
14. Supervising hood maintenance operations. This shall include assuring that radioactive materials have been removed from the hood, wipe tests have been performed, and contaminated filters are handled and disposed of properly.

B. PRINCIPAL INVESTIGATOR'S RESPONSIBILITY

In order to maintain compliance with the **<u>Texas Regulations for Control of Radiation</u>** and the University's Radioactive Materials License, and to ensure the protection of all personnel, the following procedures must be incorporated into the radiation safety program of each researcher authorized to use and possess radioactive materials and radiation producing equipment. Principal

Investigators are responsible for:

1. Submitting an application to possess and use radioactive materials or sources to the Radiation Safety Officer. No work may be performed until authorization is received. Any proposed changes in the original authorization must be submitted in writing to the Radiation Safety Officer for approval.
2. Adequate planning. Before an experiment is performed, the supervisor should determine the types and amount of radiation or radioactive material to be used. Trial runs should be made whenever practicable to determine proper procedures and to evaluate necessary radiation protection.
3. Instructing all students and employees in the use of safe techniques and in the application of approved radiation safety practices.
4. Notifying the Radiation Safety Officer in writing of new employees and students working with radioactive materials in their areas. Indicate the individual's name, birth date, social security number, training, and radioactive materials or sources to be used.
5. Ensuring that all persons using radioactive materials under his or her authorization comply with bioassay requirements, e.g., thyroid scans.
6. Using correct procedures for the purchase or transfer of radioactive materials.
7. Posting areas where radioisotopes are kept or used and where radiation fields exist.
8. Recording the receipt, use, transfer, and disposal of radioactive materials in his area.
9. Submitting an inventory of radioactive materials at three month intervals.
10. Assuring that radioisotope storage areas are locked when the user is not in attendance.
11. Providing radiation detection equipment compatible with the particular type of radiation work done in the area. A survey meter should be kept handy for "spot" monitoring wherever any procedure is being carried out with radioactive materials. The maximum permissible dose rate allowable within the radiation laboratory where personnel may be reasonably expected to spend the working day is 2 mR/hr.
12. Assuring that all radioactive waste materials are placed in the proper receptacles and that disposal slips are sent to the Radiation Safety Officer.
13. Performing weekly contamination surveys and maintaining a written record of the results of the survey. All work areas including bench and tabletops, sinks, drains, traps, floors, etc., will be included in this survey. Copies of surveys will be submitted to the Radiation Safety Office quarterly. (See Section II. G. for the methods and frequency of surveys.)
14. Having all records available for inspection by the Radiation Safety Office or the Texas Department of Health at any time during normal working hours.
15. Notifying the Radiation Safety Officer before hood maintenance is performed. Radioactive materials must be removed from the hood and

the area must be wipe tested before maintenance is performed. Contaminated filters must be properly handled and disposed.

C. INDIVIDUAL LABORATORY USER'S RESPONSIBILITY

Each individual laboratory user has the following responsibilities:

1. Keeping personal exposure to radiation **AS LOW AS REASONABLY ACHIEVABLE (ALARA)**.
2. Wearing personnel dosimeters when deemed necessary by Radiation Safety Office.
3. Utilizing all appropriate protective measures such as:

   a. Wearing the appropriate safety equipment, for example, gloves, lab coat, safety glasses, etc.
   b. Using protective barriers and other shields when possible.
   c. Using mechanical devices whenever their aid will reduce exposure.
   d. Pipetting with mechanical devices only - **NEVER PIPETTE RADIOACTIVE SOLUTIONS BY MOUTH**.
   e. Performing radioactive work within the confines of an approved hood, unless serious consideration has indicated the safety of working in the open. All iodinations are **TO BE CARRIED OUT IN A HOOD**.
   f. **NO SMOKING, DRINKING OR EATING** in radioisotope laboratories.
   g. Maintaining good personal hygiene. Do not work with radioactive materials if there is a break in the skin below the wrist. Wash hands and arms thoroughly before handling any object which goes to the mouth, nose, or eyes.
   h. Checking radiation survey instruments weekly to ensure they are in operating order.
   i. Checking at least once weekly for contamination the immediate areas, e.g., hoods, benches, etc., in which radioactive materials are being used. A log record should be maintained of these surveys, including results which are entirely negative. Any contamination observed shall be cleaned and resurveyed. (See Section II. G. for requirements.)
   j. Monitoring apparatus and work surfaces immediately after an isotope procedure is completed.
   k. Labeling all radioisotope storage containers with the following information:

(1) radioisotope
(2) activity and date
(3) authorized user
(4) caution radioactive material (with radiation symbol).

   l. Keeping the laboratory neat and clean. The work area should be free from equipment and materials not required for the immediate procedure. Keep or transport materials in such a manner as to prevent breakage or spillage (double container) and to ensure adequate shielding. Keep work surfaces covered with absorbent material to limit contamination and collect spillage in case of accident. Mark the area with tape labeled for radioactive materials.

m. Labeling and isolating radioactive waste and equipment, such as glassware used in laboratories for radioactive materials. Once used for radio-active substances, equipment should not be used for other work, and **SHALL NOT BE SENT FROM THE AREA TO CENTRAL CLEANING FACILITIES, TO REPAIR SHOPS, OR TO SURPLUS UNTIL DEMONSTRATED TO BE FREE OF CONTAMINATION**.
n. Requesting Radiation Safety Office supervision of any emergency repair of contaminated equipment in the laboratory by shop personnel or by commercial service contractors.
o. **REPORTING ACCIDENTAL INHALATION, INGESTION, OR INJURY INVOLVING RADIOACTIVE MATERIALS** to the user's supervisor and the Radiation Safety Office, and carrying out their recommended corrective measures. The individual shall cooperate in any and all attempts to evaluate the user's exposure.
p. Carrying out decontamination procedures when necessary, and taking the necessary steps to prevent the spread of contamination to other areas.
q. Complying with requests from the Radiation Safety Office for body burden measurements of the thyroid and submission of urine samples for radioassay of workers using significant quantities of both gamma and beta emitters.
r. Complying with proper procedures when terminating employment or the use of radioactive materials or radiation.

D. BASIC PRINCIPLES OF RADIATION PROTECTION

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:

1. DISTANCE: It is a known fact that the rate of radiation exposure is inversely proportional to the square of the distance from the source; thus, maintaining a large distance from a source of radiation offers a very practical avenue of protection.
2. TIME: Since accumulated dose is directly proportional to time, the less time one spends around radiation, the less radiation exposure one receives.
3. SHIELDING: Shielding offers a form of protection that requires prior planning and anticipation of safety requirements for given work. Protection offered by shielding depends on the following:

   a. Initial radiation dose rate without shield

b. Material used for shielding (the denser the material, the better it is as a shield)
c. Thickness of the shield
d. Type and energy of radiation.

E. EXPOSURE LIMITS FOR RADIATION WORKERS

The maximum permissible dose limits as per State of Texas Regulation 289.201 are specified in the following table:

1. The more limiting of:	REMS PER YEAR
a. total effective dose equivalent for whole body (i.e., all organs and tissues), or	5
b. deep dose equivalent (i.e., at 1 cm depth over body surface) plus committed dose equivalent to any organ or tissue other than lens of eye (i.e., dose equivalent that will be received during the 50-year period following intake of radio-active material)	50
2. Eye dose equivalent	15
3. Shallow dose equivalent to skin or any extremity	50

F. TYPES OF RADIATION EXPOSURE

The following principles should be taken into consideration when dealing with matters involving radiation exposure:

1. EXTERNAL SOURCES - These are sources or materials that are not in direct contact with the body, but that may expose an individual to radiation.
2. INTERNAL SOURCES - These are sources that enter the body. Radioactive materials may enter the body by four routes, namely:

   a. Ingestion with food or drinks, or with other materials which come into contact with the mouth
   b. Inhalation of radioactive gases and vapors
   c. Absorption through the skin, or by means of a break in the skin

d. Accidental injection with a needle or micropipette.

3. PROTECTION FROM EXTERNAL SOURCES - This is established by the use of shields and containers made of lead or other suitable materials; by use of distance as afforded by instruments with long handles, remote handling devices, etc.; and by reduction of time spent in the vicinity of radioactive materials through rapid and careful work.
4. PROTECTION AGAINST INTERNAL SOURCES - This is achieved by preventing the entry of radioactive materials into the body. Radioactive materials should not be permitted to contaminate the skin, nor enter into the body through a break in the skin; radioactive gases should not be released in the laboratory. Radioactive materials should not be allowed to enter the mouth.

G. BIOLOGICAL EFFECTS OF RADIATION

If an organism is given a significantly large dose of ionizing radiation within a relatively short period of time, there will be definite effects due to the irradiation. For example, a dose of several hundred rads delivered rapidly to the whole body of a mammal produces the “acute radiation syndrome” with severe illness and possibly death. Exposures of less than that required to produce the acute radiation syndrome may still produce genetic effects and will effect growth and development, the incidence of neoplasms, and the life span.

These effects have been observed at doses greatly in excess of those presently recommended by National, State, and local radiation protection agencies. At the present acceptable levels of radiation exposure, no cellular changes in mammals can be detected. However, there is no lower limit below which the amount of radiation cannot produce gene mutations.

All the aforementioned aspects of radiation damage were taken into consideration when the National Council on Radiation Protection and Measurements (NCRP), the unofficial authority on radiation protection, established recommended maximum permissible dose (MPD) values for different segments of the population. The primary objective in establishing MPD values for persons who work with radiation in their occupations is to keep their exposure well below a level at which adverse effects are likely to occur during their lifetime. Another objective is to minimize the incidence of genetic effects for the population as a whole. These dose limits do not include any doses received by an individual as a patient or from natural background radiation.

It must be emphasized that the risk to individuals exposed to a MPD or the dose limits for the population is considered to by very small; however, **RISK INCREASES WITH INCREASING DOSE**. For this reason, it is desirable to keep radiation exposure as low as achievable with due consideration to feasibility and efficiency of operation.

H. PERSONNEL MONITORING

Film badges are to be worn by all personnel in areas where the dose rate is above 2.0 mR/hr or when they are using a source of radiation (except H-3 and C-14). These film badges shall be changed and processed each month. Records of the dose received during the month, quarterly accumulations, and a total accumulated dose for each individual shall be maintained by the Radiation Safety Officer. Individuals receiving ten percent of the allowable limit in any calendar quarter will be notified.

The film badge provides a means of measuring the dose of radiation received. It does not provide protection from radiation. It should be worn on the trunk of the body, preferably on the lapel. However, in situations where lead aprons are worn, two film badges should be required. One should be worn UNDER the apron for the purpose of recording whole body radiation exposure. A second film badge should be worn outside of the lead apron to measure exposure to the head and extremities. If a single badge is worn, it should be placed outside the lead apron.

The following parameters will help determine who will need film badges:

1. Any person likely to receive 10% of the quarterly allowable limit
2. Any person working with millicurie amounts of a beta emitter with energies greater than 1 MeV
3. Any person working with greater than 10 millicuries of a gamma emitter with energy less than 100 keV
4. Any person working with millicurie amounts of a gamma emitter with energies greater than 100 kev

Requests for film badge service for authorized users shall be made to the Radiation Safety Officer on Form RS-02. Copies of the form are available in the Radiation Safety Office or can be made from this manual. (See following page for a sample form.)

The lapel badge consists of a light-tight, paper packet containing a radiation sensitive film. For routine use, the packet is enclosed in the plastic clip-on holder. The holder contains metal filters or absorbers of different densities and thicknesses that absorb radiation of varying energies. There is also an open-window in the holder. Beta and weak gamma radiation can be detected in this area.

Films are processed and analyzed along with films which have not been exposed to any man-made radiation other than normal background. A comparison of the personnel film to the standards and backgrounds permits an evaluation of exposure as a function of kind and energy of the radiation.

Wrist badges and ring badges are available for use when radiation exposure to hands and forearms is expected to be significant. Wrist or ring badges will be issued to persons using millicurie amounts of hard beta emitter or gamma emitter.

I. BIOASSAYS

Bioassays may be required by the Radiation Safety Officer for persons handling certain radioisotopes. In general, bioassays will be required of persons handling stock solutions or otherwise directly involved in experimental procedures in which there exists the possibility of internal deposition of radionuclides. Bioassay procedures include thyroid uptake analyses and the radioanalysis of urine. Reports of the bioassay become a part of an individual's exposure history and are kept on file in the Radiation Safety Office.

Bioassays after Exposure to Tritium

Persons handling 100 millicuries of tritiated (H-3) materials must make arrangements with the Radiation Safety Officer for a urine bioassay. A urine sample must be submitted within 24 hours following the exposure. The maximum allowable concentration of H-3 in urine is 2.9 microcuries per liter. The results of the analysis will be kept on file.

Thyroid Uptakes for Users of Radioiodine

Persons planning to use radioiodine are to contact the Radiation Safety Office regarding the thyroid bioassay program. Arrangements will be made for routine thyroid uptake measurements at the University of Texas Southwest Medical Center. This simple, non-invasive procedure requires only a few minutes to complete. A baseline measurement shall be obtained prior to the initial use of unbound radioactive iodine. It is recommended that a thyroid survey be arranged following the first use of unbound radioiodine. Subsequently, during continued usage, thyroid uptakes are required at scheduled quarterly intervals. In addition, individuals should call the Radiation Safety Office if they suspect that they have been exposed to airborne radioiodine or if they believe that they might have ingested or otherwise have allowed radioiodine to enter their bodies. For iodine concentrations in the thyroid gland, the maximum permissible thyroid burden is 1150 nanocuries, corresponding to a thyroid dose of 5 rem/year.

J. PROTECTIVE APPAREL

Protective apparel includes laboratory coats, overalls, gloves, shoe covers, safety glasses, and respirators. For routine work, laboratory coats, gloves, and safety glasses will provide adequate protection. The following precautions are to be followed for laboratory coats intended to be used while working with radioactive materials:

1. The laboratory coats should be worn buttoned.
2. The laboratory coats should **NOT** be worn out of the laboratory area.
3. The laboratory coats should **NOT** be stored with street clothes.
4. The laboratory coats should be decontaminated or disposed of if the contamination exceeds background significantly. If a lab coat is contaminated the RSO should be advised and a disposal method determined.

K. ACCIDENTAL SPILLAGE

In the event of accidental spillage, the following procedures will be carried out immediately:

1. If necessary, notify all personnel to vacate the area.
2. Notify the Radiation Safety Officer at Extension 6111 of the nature of the spill, i.e., location (room number); identity of the radioisotope; a realistic estimate of the activity (in microcuries); and the chemical or physical form. The Radiation Safety Officer will evaluate the extent of the problem and will assist if necessary.
3. Tackle the job immediately. Promptness is usually rewarded with easier and more decontamination.
4. Put on rubber gloves. Blot the spilled liquid with absorbent paper. Do not wipe or use a wiping motion, as this enlarges the area of the spill. Avoid stepping in the spilled liquid.
5. Once the affected area has been blotted dry, scrub the contaminated area with soap and water. Blot wash water from the surface with absorbent paper. Continue this process until the dose rate of the periphery of the area is not more than 2 mR/hr. If the contaminated area cannot be reduced to these levels and the active material has a short half-life (30 days or less), encircle the contaminated area with a red mark and place written instructions for personnel to keep away until the activity has decayed to less than 2 mR/hr. If the contaminated area is in an unrestricted location, barricades will be used to restrict access of unauthorized personnel.
6. If the active material has a long half-life, it may be advisable to remove a layer of material from the contaminated surface. Consult the Radiation Safety Officer.
7. Contaminated clothing and other items which are not disposable shall be wrapped in nonabsorbent paper and stored in an unoccupied place until the activity has decayed to a safe level. Wear rubber gloves while handling such items.

RADIATION EMERGENCY PROCEDURES

EMERGENCY TYPE	HAZARD	IMMEDIATE PRECAUTIONS	FOLLOW-UP
Minor Spills (Usually microcurie amounts)	**<u>Radiation</u>:** No immediate radiation hazard to personnel. **<u>Contamination</u>:** Low	1. Notify all persons in the room. 2. Confine spill immediately. 3. Notify Radiation Safety Office, Ext. 6111	Permit no one to work in area until approved by Radiation Safety Office.
Major Spills (Usually millicurie amounts)	**<u>Radiation</u>:** May be great hazard to personnel. **<u>Contamination</u>**: Great hazard to personnel and equipment.	1. Notify all personnel to vacate room or area. 2. Make <u>NO</u> attempt to clean up the spill. 3. Switch off all fans and vacate room or area. 4. Provide temporary barricade and post warning signs. 5. Notify Radiation Safety Office, Ext. 6111.	Decontamination of personnel and equipment, including spill, to be carried out by or under supervision of Radiation Safety Office.
Accidents Involving: Dust Mist Fumes Vapors Gases	**<u>Radiation</u>:** Internal hazard due to possible ingestion. **<u>Contamination</u>:** Easily spread when airborne.	1. Notify others to vacate room or area. 2. Close windows and doors shut off all circulating devices. 3. Provide temporary barricade and post warning signs. 4. Notify Radiation Safety Office, Ext. 6111	Do not re-enter until approved by Radiation Safety Office.
Injuries Involving: Radiation Hazard Contamination	**<u>Contamination</u>:** Wounds usually greatest hazard.	1. Wash wound immediately in running water. 2. Call physician 3. Notify Radiation Safety Office, Ext. 6111.	Permit no one involved in accident to return to work until approved by physician or Radiation Safety Office.
Fires Involving: Radioactivity	**<u>Radiation</u>:** Internal hazard from airborne activity.	1. Notify all persons in room and building at once. 2. Attempt to extinguish fire if radiation hazard is known not to be immediately	Emergency activities will be governed by or handled in cooperation with the Radiation Safety Office.

		present. 3. Initiate fire alarm. 4. Notify Radiation Safety Office, Ext. 6111.	

IN ALL EMERGENCIES, NOTIFY THE RADIATION SAFETY OFFICE, Ext. 6111

SECTION II: UNIVERSITY REGULATIONS GOVERNING THE

USE OF RADIOACTIVE MATERIALS

A. UNIVERSITY TRAINING REQUIREMENTS TO USE RADIOACTIVE MATERIAL

New personnel at The University of Texas at Dallas who will be using radioactive material or will be working in a laboratory using radioactive material will be required to attend an orientation session prior to beginning radiochemical work. These sessions will be scheduled as needed. Contact the Radiation Safety Office at Ext. 6111 for details.

In addition, personnel handling radioactive material under a licensed investigator must satisfy one of the three following criteria:

1. Attend a specific eight hour course offered by the Radiation Safety Officer. Topics will include atomic structure and radioactivity, units of radiation protection, dosimeters, proper use of survey instruments, sealed sources, properties of X-rays, federal and state regulations, and operating and emergency procedures.

2. Have completed a radiation safety course at another university. (This course must be acceptable to the Radiation Safety Officer.)

3. Pass a written exam administered by the Radiation Safety Officer covering the contents of the course.

The licensed investigator is responsible for on the job training of specific procedures to be used in experimental work. Copies of written procedures should be available in each laboratory.

B. APPLICATION FOR LICENSE

Applications for possession and use of radioactive materials are to be made on Radiation Safety Officer's Form RS-01, copies of which are available in the Radiation Safety Office. A facsimile of Form RS-01, Parts A and B, is shown in Figures 1 and 2. Form RS-01 is to be completed for the initial application of a prospective user, and is required when the user makes changes in equipment, facilities, or procedures. An investigator who is already authorized to use one or more radioisotopes and wishes to extend his coverage must complete only Part A (the first page) of Form RS-01. An example of a completed application, Part B, is shown in Figure 3. Individual items in the form are to be completed according to the following instructions:

INFORMATION REQUIRED

Item No.

1. The name, date of birth, and Social Security number of the person who will be responsible for the safe handling of the radioactive material. The applicant must be experienced in safe handling as evidenced by entries on Part B. If such information is already on file in a previous application, it need not be repeated.

2. The location (building and room number), department, and telephone extension where the radioactive material will be used.

3. Radioisotopes and their half-lives may be identified by conventional symbolism, such as Cr-51, 27.8d; C-14, 5730 yr., etc. An application is to be used to request the use of only ONE radioisotope. The "quality" noted SHALL be the maximum quantity expected to be on hand at any time expressed in millicuries. The maximum quantity should include materials being held in waste containers, and, thus, is the total inventory of radioactive material held by the investigator. The "form" should be the description of the chemical compound or physical form of the material as it will be received for use. If more than one chemical or physical form of a particular radioisotope is desired, a separate possession limit should be stated for each. If several different forms may be used during the course of the experimental work, the application may state "any form." If the radioactive material is contained in a sealed source, give the manufacturer's name and the model number of the source.

4. State briefly the use and plan of investigation of the radioisotope and each chemical and physical form specified in Item 3. If additional space is needed, a second sheet may be attached.

5. State the plan to be used for personnel monitoring and radiation protection beyond the use of film badges, which are issued routinely. Summarize briefly information on shielded storage facilities, special handling apparatus, and experimental procedures designed to reduce exposure to personnel, minimize contamination, and safeguard the radioactive material.

6. If the applicant follows the radioactive waste disposal program, the applicant need merely enter this reference in Item 6.

If exceptions to the standard procedures are expected, the applicant must outline these exceptions in Item 6.

7. Include all pertinent TRAINING in Parts A through D of Item 7. All training in specialty fields related to use of radioactive materials should be included, if appropriate.

8. All pertinent experience with radioactive materials or other source of radiation should be included.

9. The names of the laboratory technicians, research associates, and others who will assist in the work with this radioisotope, including their experience 9(b) and training 9(c) should be listed.

10. List the analytical and survey types of instrumentation that will be used or is available for use during the course of the experiment.

FORM NO. RS-01, PART C

Diagram the laboratory showing the location of fume hoods, sinks, counting equipment, radioisotope storage containers, etc., and indicate that portion of the work surface or bench tops to be set aside for work with radioactive materials. Figure 4 is an example of a typical laboratory diagram.

APPROVAL OF APPLICATION

When completed, Form RS-01, Parts A, B, and C, should be submitted to the Radiation Officer for review. After endorsement by the Radiation Safety

Office, a request for license amendment will be submitted to the Texas Department of Health, Bureau of Radiation Control. Upon receipt of an amendment, the Radiation Safety Officer will notify the applicant in writing. Work done with radioactive materials must be in strict compliance with the conditions of UTD's Academic License and with this Radiation Safety Handbook. If research uses occur which materially compromise radiation safety, the Radiation Safety Officer may suspend or withdraw approval of a researcher to possess the use of radioactive materials.

C. PROCEDURES FOR ORDERING AND RECEIPT OF RADIOACTIVE MATERIALS

1. Ordering Radioactive Material

a. All purchase orders for radioactive materials must be signed by the licensed investigator responsible for its use.

b. All purchase requisitions are to be sent to the Radiation Safety Office for approval prior to being sent to the Purchasing Dept. All requisitions for radioactive materials must be signed by the Radiation Safety Officer.

c. Once approved, requests will be forwarded to the Purchasing Office.

Each supplier of radioactive material is required by State and Federal regulations to validate the University's license to possess and use such material. This is accomplished by filing a copy of the University's Academic License with each such supplier. The Radiation Safety Officer will supply copies.

2. Receiving of Radioactive Materials

a. Upon receipt of radioactive material, the individual licensed user must monitor the external surfaces of the package both for radiation levels, using a Geiger counter, and for radioactive contamination, using a wipe test. Records of these surveys shall be maintained by the licensed user for periodic review. If surface contamination exceeds 22 dpm/cm^2, when averaged over a 300 cm^2 area, or external radiation levels exceed 200 mrem/hr, at any point on the surface, the Radiation Safety Officer shall be immediately notified. Monitoring for surface contamination and radiation levels must be performed as soon as practicable after receipt of the package, but not later than three hours after the package is received if it is received during normal working hours or not later than three hours from the beginning of the next working day if it is received after working hours.

b. As the package is opened, the surfaces of containers and packing materials shall be monitored for radioactive contamination as described in Section I.C.2.a.

c. The purchase order number shall be assigned to the radioactive material as an identification number.

d. A copy of the signed receiving report shall be forwarded to the Radiation Safety Officer.

3. Keeping a Log Book

State regulations require that the University have available for inspection a record of all radioactive material on hand. Such records cannot be maintained by the Radiation Safety Office because, by their nature, they represent a dynamic condition of new supply, use, disposal, and radioactive decay.

Individual licensed users must keep a current inventory of all materials for which they are responsible; and they must keep this record in a form that permits convenient, periodic review. This requirement is satisfied by very simple bookkeeping procedures.

The inventory record required of each licensed user must detail the Date of Receipt, Isotope, Activity, Chemical Compound or Physical Form, From whom Received, Use, and Disposal of the Material. By referring to the entries, it should be possible to determine what portion is in storage; what portion is incorporated in experiments; what portion has been discarded and by what means; and what portion has been lost by radioactive decay. When portions cannot be determined exactly, be realistic and practical when making estimates. It is important that each investigator be able to account for the total amount of material received. On a quarterly basis inventories must be submitted to the Radiation Safety Office giving current accounts of materials on hand and amounts disposed of in the previous quarter. No new purchase requisitions will be approved for investigators more than 3 months in arrears of inventories. These records must be maintained so that the University may remain in compliance with the State regulations.

D. WHERE RADIOACTIVE MATERIALS ARE USED

Radioactive materials are to be used only in those facilities which have been approved by the Radiation Safety Officer. Investigators wishing to expand their areas approved for radioactive materials or investigators moving to new locations must submit a description of the area, including fixtures, storage areas, and other facilities.

TRANSFER OF RADIOISOTOPES

On Campus Transfers: Radioactive material is **NOT** to be transferred from one investigator to another without the approval and authorization of the Radiation Safety Officer, since approval for use of radioactive materials is given only for the original working area and the original investigator.

Off Campus Transfers: Radioactive material shall **NOT** be shipped or transferred to or from the University of Texas at Dallas without the approval of the Radiation Safety Officer.

TERMINATION OF RADIOACTIVE MATERIAL USE

Upon termination of association with the University, a principal investigator must complete the following steps:

1. Submit a notice of termination to the Radiation Safety Officer.

2. Account for radioactive material in his possession and arrange for final disposition.

3. Arrange for pickup of all radioactive waste.

4. Request a clearance survey of the laboratory.

5. Return all personnel dosimeters.

E. REQUIREMENTS FOR LABORATORIES USING RADIOACTIVE MATERIALS

In order to maintain compliance with the Texas Regulations for Control of Radiation and the University's Radioactive Materials License, and to insure the protection for all personnel, the following conditions must be incorporated into each radiation safety program authorized to use and possess radioactive materials and radiation producing equipment:

1. Laboratory areas shall have the following items posted:

   a. "Notice to Employees" form
   b. Emergency telephone numbers for accidents involving radiation

c. Where copies of the license, regulations, inspections reports, etc., may be found

d. A copy of emergency procedures.

2. Control of access into restricted areas is the responsibility of the faculty member supervising the project.

3. Smoking, drinking, or eating will not be allowed in areas where radioactive materials are used or stored.

4. Trial runs should be made whenever practicable to determine proper procedures and to evaluate necessary radiation protection.

5. A survey meter shall be kept handy for “spot” monitoring whenever any procedure is being carried out in the laboratory. The maximum permissible dose rate allowable within the radiation laboratory where personnel may be reasonably expected to spend the working day is 2 mR/hr.

6. Work involving liquid radioisotopes should be performed on trays lined with absorbent paper or on surfaces protected with plastic-backed absorbent paper. The area should be marked off with radiation labeled tape.

7. Radioactive materials will not be handled with bare hands, nor will sealed sources be opened.

8. Long-handled tongs, gloves, lab coats, shoe covers, respirators, and other equipment are to be used whenever such safety measures are needed. When in doubt as to whether special equipment is necessary, the user should contact the Radiation Safety Officer for assistance.

9. Gloves and lab coats should be worn by all employees when working with liquid radioactive materials. In addition, a respirator should be worn by all employees working with gaseous or powdered radioactive materials.

10. Safety glasses, optical glasses, or goggles should be worn when handling 500 microcuries of hard beta-emitting radioisotopes.

11. Chemical hoods in which radioactive materials are used must have a minimum air velocity of 100 linear feet per minute at the face and a negative pressure differential. Physical Plant will verify the velocity of hoods once a year or at the request of the user.

12. All transfers and dilutions should be performed in functioning exhaust hoods or glove boxes. (See Appendix 1 for specifics on quantities to be handled in hoods and glove boxes.)

13. Bottles, flasks, beakers, and other vessels that contain more than 100 microcuries of activity should not be picked up by hand for more than a few seconds. Always use tongs or forceps.

14. Radioactive materials that emit gamma rays and whose activity exceeds 500 microcuries shall be kept behind shields or inside lead-lined vessels.

15. Mouth pipetting of liquid radioisotopes is forbidden. Use a rubber bulb or similar device.

16. All glassware and equipment containing radioactive materials should be properly labeled.

17. Apparatus and work surfaces should be monitored immediately after an isotope procedure is completed.

18. Protective clothing and hands are to be monitored upon completion of laboratory work involving the handling of unsealed radioisotopes.

19. Radioactive material in liquid form should be stored and transported in double containers.

20. Radioisotopes are to be stored in a secured

manner. Material stored in a refrigerator or freezer in a hallway

1. must be equipped with a locking device and must be kept locked.

21. Label refrigerators, freezers, and fume hoods where radioisotopes are stored.

22. In cases where refrigerators or freezers are stored in hallways having unrestricted access, wipe tests are necessary daily (or after each use, if less frequent than daily).

23. Employees must wash their hands thoroughly before smoking, eating, or leaving the area where unsealed radioisotopes are being used. Hands should be monitored before leaving the lab.

F. RADIOACTIVE WASTE DISPOSAL PROGRAM

All radioactive wastes resulting from the use of radio-isotopes in UTD laboratories **SHALL** be disposed of in such a way as to prevent the occurrence of a hazard to the health of personnel, to the value of property, or to the welfare of the community. Adherence to the recommendations and requirements established in the succeeding sections will achieve these goals, as well as ensure compliance with the Texas Regulations for Control of Radiation (TRCR).

It is the responsibility of each licensed investigator to insure the proper disposal of all radioactive material under his or her authorization. Therefore, each licensed investigator is required to implement an effective radioactive waste management program within the laboratory. Contaminated waste falls into three categories: dry or semi-solid, liquid, and scintillation vials. Furthermore, waste should be separated by half-lives. Those isotopes with half-lives less **than 88 days** may be stored for 10 half-lives. The radioactive material in this category can be decayed to a level suitable for disposal as ordinary trash. Isotopes with half-lives longer than **88** days must be disposed of in barrels shipped to approved radioactive waste sites. When discarding packing materials used for shipment of radioactive material or when discarding short-lived isotopes which have been decayed, remove or obliterate all radiation labels.

When contaminated waste containers are ready for removal from the laboratory, a disposal form must be completed and submitted to the Radiation Safety Officer for material being placed in barrels for permanent disposal. The material then should be removed from the laboratories. For material taken to storage for decay, an entry must be made in the storage and disposal log kept at the storage facility. An entry in the log is also required when the waste is disposed of after decay.

DRY AND SEMI-SOLID WASTE DISPOSAL

The classification of laboratory wastes as dry and semi-solid is a broad one, and likely will comprise the majority of the waste generated. The category consists of **ANY** and **ALL** disposable lab ware that has come into contact with radioactive materials. Specifically, such items include, but are not necessarily restricted to: absorbent work surface coverings and/or other protective coverings; plastic/rubber gloves and tubing; syringes; glassware such as pipettes, beakers, flasks, columns, capillary tubes; and so forth.

When accumulating contaminated dry waste in the laboratory, the licensed investigator shall:

1. Provide adequate and properly labeled receptacles for radioactive wastes.

2. Ensure that radioactive wastes are placed in their assigned receptacles, and are **NOT** disposed of as ordinary wastes.

3. Maintain written inventory records of the activity (in microcuries, or multiples thereof) of all contaminated wastes removed from the laboratory.

With dry contaminated waste containers, the following precautions must be followed:

1. Label all bags with a tag showing the date, isotope, its quantity, and name of the principal investigator from whose lab it came. These records should correspond to the comparable entries on the laboratory inventory record.

2. Carefully inspect plastic bags for leaks prior to moving them to the waste barrels or storage area.

3. Take precautions to ensure that capillary tubes, pipettes, or other sharp objects do not puncture the plastic waste bag.

4. Do **NOT** under any circumstances place radioactive waste in halls where it might be picked up by housekeeping personnel.

LIQUID RADIOACTIVE WASTE DISPOSAL

The storage and disposal of liquid waste requires an extra measure of care. Recommendations governing the storage and handling of liquid wastes in the lab are listed as follows:

1. Select a remote but accessible location of the lab for the liquid waste vessel. (Mark the area conspicuously with radioactive materials warning signs.)

2. A heavy gauge plastic carboy with a wide mouth is recommended. Be judicious in the selection of plastics, since many are soluble in organic solvents. Some of those that are relatively inert and have good chemical resistance to toluene, phenyls, esters, ketones, and alcohols are unmodified polypropylene, polytetra-fluorethylene (Teflon), and polytrifluorochlorethylene.

3. The use of metal cans for radioactive liquid storage vessels is not recommended. First the metal is attacked if the liquid becomes acidic. Second, it is difficult to tell how much liquid is inside which can result in spills as the can is “topped off.”

4. The use of glass for radioactive liquid storage is not allowed. The only advantage to glass as a container is that it is inert in the presence of just about everything. This advantage becomes meager, indeed, considering the high risk of breakage and the potential for contaminating large areas.

5. Provide for double containment of the liquid waste container as a precaution against leakage and to avoid spillage during pouring, which is usually accompanied by drips, dribbles, and seeping.

6. All liquids containing measurable quantities of radio-activity must be collected and disposed of in the designated waste containers. Small quantities of low-level waste, such as waste tritium and carbon-14 solutions containing less than 0.05 microcuries/gram, can be disposed of in the sanitary sewer system, as specified in Part 21.1003 of the TRCR, provided it is in a non-toxic medium.

If a toluene based cocktail or other hazardous solvents are used, the medium is a "mixed waste" and must be disposed of as a mixed radioactive and hazardous waste. Store organic solvents separately from aqueous based liquids. Label all containers carefully.

The licensed investigator is responsible for maintaining an inventory record of all quantities or radioactive liquids disposed of into the sanitary sewer system. The log shall record the date of disposal and the identity and quantity of the radionuclide, and shall specify the water soluble chemical form of the material. Routine surveys will be done to sink traps in the laboratory. The maxims of safe radioactive liquid waste disposal by either of the two acceptable methods are:

DO exercise care when handling liquids in any quantity.

DO record all disposals in your log book.

DO use double containment when moving liquid wastes.

DO NOT pour liquid scintillation cocktails in the sink. Toluene based scintillators are NOT water soluble.

DISPOSAL OF USED SCINTILLATION VIALS

Liquid scintillation vials will be replaced into trays and boxed. Vial boxes are to be conspicuously and properly labeled. Vials, empty or full, will **NOT** be placed in the solid waste drums. They must be packed in specially marked barrels for used scintillation vials. They are to be disposed of in these barrels in the following manner:

1. If the barrel is empty, pour in about one cubic foot (28 liters) of vermiculite. Empty the scintillation vials from their cardboard flats into the barrel.

2. On top of the vials, pour in another cubic foot of vermiculite, or a quantity sufficient to completely cover the vials.

3. Another layer of the same quantity of vials may

now be emptied into the barrel, and following this, another quantity of vermiculite sufficient to cover the vials.

4. The empty cardboard boxes used to transport the vials to the waste room may now be disposed of as ordinary waste.

G. METHODS AND FREQUENCY FOR CONDUCTING RADIATION SURVEYS

When radioactive material is handled in the form of solutions or powders, as may occur in a laboratory, both radiation surveys and contamination surveys should be performed to prevent unnecessary radiation exposure to personnel and to prevent the spread of contamination throughout the facility. Radiation surveys are performed by using a radiation survey meter, and contamination surveys are performed by taking wipe samples from surfaces in the facility that are likely to be contaminated.

FREQUENCY OF SURVEYS

The frequency of surveys depends upon the amount and type of radioactive material used. Listed below are examples which may be useful in determining how often to perform surveys. The greater the work load, the more often the surveys should be performed.

1. Low Level Areas: Not less than once a month. These are areas such as where in vitro tests are performed, samples analyzed, etc. (samples usually less than 100 microcuries each).

2. Medium Level Areas: Not less than once a week. These are areas where millicurie amounts of material are handled.

3. High Level Areas: Not less than once a day. These are areas used for storage of active solutions, preparation of materials, fume hoods, etc. (usually curie amounts).

NOTE: In cases where refrigerators or freezers are stored in hallways having unrestricted access, wipe tests are necessary daily (or after each use if less frequent than daily). In areas which will be released for unrestricted use (laboratories and equipment by other classes), daily wipe tests shall be performed.

METHODS OF SURVEYS

Suggested methods for performing these two types of surveys are given below. Records of these surveys should be maintained for inspection by the Texas Department of Health and for reference to determine whether the radiation levels or the contamination levels remain constant or increase over a given period of time.

1. Radiation Level Surveys

A survey meter capable of measuring levels as low as 0.1 mR/h should be used and the results recorded on a standard form showing location, date, person performing survey, instrument used, exposure levels, and corrective action taken, if any. A sketch of the area should be used to make an easily prepared and easily understood survey record when annotated with this information.

2. Contamination Level Surveys

A series of wipes using filter papers or swatches of cloth should be taken from those surfaces where contamination could be expected to exist or where radiation levels are fairly high. (Areas where solutions are prepared, incoming packages received, pipetting is performed, etc., are areas that may be contaminated.) The wipes should be numbered or labeled and their location indicated on the sketch record as described above. The wipes should each be rubbed over a surface area of about 100 square centimeters to maintain a consistent means of determining the amount of removable contamination. The wipes may be counted using a gamma scintillation well counter, a Geiger counter, or any other detector capable of detecting the small amount of contamination on the sample. (A civil defense CDV-700 meter using an open beta window should be adequate.) Results should be converted from CPS to CPM to microcuries of contamination for reporting purposes.

ACCEPTABLE LIMITS

1. Radiation Levels

In no area that is unrestricted (uncontrolled) should radiation levels exist such that a person could receive 500 mR in any one year, 100 mR in any seven consecutive days, or 2 mR in any one hour. If such areas are found, measures should be taken to eliminate the excessive radiation levels. Additional shielding or relocation of radioactive material may be required. For restricted areas, the applicant should establish acceptable radiation levels that are as low as reasonably achievable.

2. Contamination Limits

If the wipe samples counted indicate more than 1,000 disintegrations per minute (dpm), the area should be cleaned until the contamination has been removed. Since it is difficult to determine exactly when a wipe sample has 1,000 dpm, it is recommended that, when such samples show an easily detectable amount of activity above background, the contaminated areas be cleaned. This action should help prevent the spread of contamination and the ingestion of contamination by personnel whose hands or clothing become contaminated.

H. RADIATION SURVEY METERS

Radiation monitoring and survey instruments will be calibrated at intervals not exceeding one year, or more often in the event that the response of the instrument becomes suspect. Calibrations will be carried out by firms licensed and registered by the Texas Department of Health.

After the instrument has been calibrated, a tag will be affixed to the survey meter indicating the date of calibration, the instrument serial number, and the name of the person who performed the calibration.

I. TESTS FOR LEAKAGE AND CONTAMINATION OF SEALED SOURCES

All sources of radioactive material that have been encapsulated to prevent the escape of the contained material and Ni-63 foil shall be tested every six months to ensure the integrity of the containment. In the absence of a certificate from a manufacturer indicating that a leak test has been made prior to shipment or transfer, the sealed source shall not be put into use until tested.

Tests for leakage and/or contamination shall be performed by the Radiation Safety Officer or his designated alternate, specifically authorized to perform such tests.

The leak test will consist of wiping with an absorbent material the surface of the source or the most accessible surface of the device in which the source is stored or mounted and on which contamination may be expected to accumulate. The wipe sample shall be treated according to the appropriate procedures necessary in order to subject it to analysis in a liquid scintillation counting system, and/or a well-type scintillation counter, depending upon the radioactive isotope encapsulated. Results of the leak test shall be calculated in units of microcuries.

Reports of the leak test shall be filed in the Radiation Safety Office and maintained for inspection by the Texas Department of Health. Any attendant calculation will also be retained as part of this file. Hard copy records (print-outs) from the analytical instrumentation used to count the smears will contain the following information:

1. For Liquid Scintillation Counting
    a. Sample identification
    b. External Standard Ratio (from which the counter efficiency is obtained)
    c. Counting period (minutes or fractions)
    d. Total counts per minute (counts per minute less background count rate).

2. For Gamma Counting or MCA
    a. Sample identification
    b. Counting period (minutes or fractions)
    c. Gross counts in any channel selected
    d. Gross counts in any energy interval selected (regions of interest).

Removable leakage contamination of 0.005 microcuries or more from any type source shall cause the source to be withdrawn from use and isolated for decontamination, repair, or disposal in accordance with the **Texas Regulations for Control of Radiation, 289.201 G.**

SECTION III: RADIATION PRODUCING DEVICES

A. IONIZING RADIATION PRODUCING DEVICES

1. AUTHORIZATION: By faculty member in charge.
2. REGISTRATION: The Radiation Safety Officer registers all radiation machines with the Texas Department of Health.
3. SURVEYS: The RSO conducts all radiation surveys.
4. TRAINING: Training requirements for radiographer trainees are given in Appendix 31-A of the Texas Regulations for Control of Radiation.
5. PURCHASING: All purchase orders for radiation machines must be approved by the RSO.

B. IONIZING RADIATION PRODUCING DEVICES REGULATIONS

Regulations for operation of equipment which produce ionizing radiation by electromagnetic waves are as follows:

1. All persons operating or using radiation machines must wear a dosimetry device. See the Radiation Safety Officer for details.
2. All persons included in #1 must be authorized by the faculty member in charge.
3. All radiation machines must be registered with the Texas State Department of Health, Radiation Control Branch. The RSO will fill out the necessary forms and check the machine for compliance.
4. All radiation machines must be checked for leakage by the RSO every 6 months.
5. All changes made in the radiation machines, which changes information on the certificate of registration, must be reported to the Texas Department of Health in writing within 30 days.
6. All new radiation machines must be checked by the RSO after installation is complete. The RSO must apply for registration within 30 days after

operation has commenced.

7. Any machine which produces X-rays incidental to its operation for other purposes is exempt from this part IF the dose does not exceed 0.5 millirem per hour at 5 cm from any accessible surface (averaged over 20 square cm).
8. Any person who transfers a radiation machine to another person must report to the Texas Department of Health the following information:

    a. Name and address of recipient
    b. Mfg., model, and serial number of the radiation machine
    c. Date of transfer.

9. All radiation machines of the particle acceleration type must have:

    a. Operators trained in radiation safety who have been provided with copies of **TRCR Regs 289.202 and 289.203** and received instruction in same
    b. Operators trained in the use of the particle acceleration, related equipment, and survey instruments
    c. Operating and emergency procedures
    d. Pertinent conditions from the Certificate of Registration provided to the operator.

10. Radiation dose limits for workers is the same for particle accelerators as for radioactive materials, given in 289.202.F.
11. All particle accelerators which produce 100 mR/hr or more must have:

    a. Interlocks to reduce the radiation level below this figure for entrance into the area
    b. Flashing lights
    c. Audible warning device activate for 15 seconds prior to operation
    d. Radiation Caution signs at all entrances.

12. All particle accelerators must have:

    a. Locks to prevent unauthorized use
    b. A switch on the control console to energize the beam (not by interlock switch)
    c. All safety devices tested every 3 months and records kept
    d. Electric circuit diagrams available for Texas Department of Health inspection
    e. A copy of the operating and emergency procedures at the control panel
    f. Approval of the RSO to bypass any interlock and be recorded in a permanent log and posted on the control panel and terminated as soon as possible.

13. All particle accelerator facilities must have:

   a. Portable radiation monitoring equipment calibrated each year and tested daily for proper operation
   b. A radiation protection survey made when any changes are made as to shielding, operation, or occupancy of adjacent areas
   c. An area monitor which must be calibrated quarterly
   d. A continuous monitor for all high radiation areas which is electrically independent of the accelerator and in full view of those present.

C. X-RADIATION PRODUCING DEVICES

In the event that any person is suspected of being exposed to X-radiation in excess of the limits specified in Section III-B of this manual, the following steps should be taken:

1. Turn off the X-ray generator or electron microscope immediately.
2. Do not change voltage or current controls or alter the position of the tube head, so that the conditions of irradiation may be duplicated to determine the extent of the radiation exposure.

D. PARTICLE ACCELERATORS

If any malfunction of the accelerators occurs, the result is a decrease in beam and radiation intensity.

Use the emergency cutoff switches to shut down the appropriate accelerator. The switches are prominently labeled as such.

Evacuation: If any emergency arises, e.g., a large leakage of tritium, an audible warning will be sounded in the building as notification to personnel to leave the building immediately.

The University RSO will be notified immediately of the emergency situation.

No re-entry will be made into the accelerator environment until a suitable evaluation has been made of the existing conditions in the building.

E. TRAINING OUTLINE FOR X-RADIATION EQUIPMENT OPERATORS

1. Fundamentals of X-Radiation Safety

a. Characteristics of X-radiation
b. Units of radiation dose (milliroentgen, millirem) and quantity of radioactivity (curies)
c. Significance of radiation dose

(1) Radiation protection standards
(2) Biological effects of radiation dose

d. Levels of radiation from sources of radiation
e. Methods of controlling radiation dose

(1) Working time
(2) Working distance
(3) Shielding
(4) Monitoring

2. Radiation Detection Instruments

a. Use of radiation survey instruments

(1) Operation
(2) Calibration
(3) Limitations

b. Survey techniques
c. Use of personnel monitoring equipment

(1) Film badges
(2) Thermoluminescent dosimeters
(3) Pocket dosimeters

3. Texas Regulations for Control of Radiation (TRCR)

a. Registration
b. Surveys (initial and routine)
c. Record keeping
d. Personnel monitoring
e. Notice to Workers Form 203-1

1. Registrant's Written Operating and Emergency Procedures
2. The University of Texas at Dallas Radiation Safety Manual
3. Examination

Appendix 1

RADIOTOXICITY OF SOME COMMONLY USED ISOTOPES

The International Council on Radiation Protection has established radionuclide activity levels above which certain safeguards may be required. We have adopted their recommendations as guidelines in the use of radiomaterials here at the University. The following table arranges some of the more commonly used radionuclides according to intrinsic radiotoxicity along with the respective radioactivity levels above which the use of a ventilated chemical fume hood or glove box is required.

ISOTOPE	FUME HOOD	GLOVE BOX
^{3}H	1 Ci	10 Ci
^{14}C	1 Ci	10 Ci
^{51}Cr	100 mCi	1 Ci
^{35}S	10 mCi	100 mCi
^{125}I	10 mCi	100 mCi
^{32}P	1 mCi	10 mCi
^{45}Ca	1 mCi	10 mCi
^{131}I	1 mCi	10 mCi

All iodinations using radioactive sodium iodide in even less than the above ICRP guideline activity values are to be performed in a fume hood.

In addition, the potential hazards involved in the use of P-32 cannot be over emphasized due to its high energy (1.71 Mev) beta emission. P-32 must be kept in a well shielded and isolated storage area when not being used, and tongs should be employed when transfers are made. The most effective shielding for P-32 is 1 cm thick Plexiglas.

The Radiation Safety Officer is available should you feel the need for assistance or additional information.

Appendix 2

RADIOACTIVE IODINE CONTROLS

PLEASE NOTE: This information pertains specifically to I-125. The use of I-131 would require additional safeguards (e.g., greater shield thickness for its more energetic gamma radiation, half-life of 8 days, etc.).

A. CHARACTERISTICS OF I-125

I-125 decays with a half-life of 60 days. It emits soft gamma radiation (Emax = 35.4 keV) and various conversion and Auger electrons with a maximum energy of 34.6 keV. The decay proceeds in two steps: (1) transmutation by electron capture, with a half-life of 60.0± 0.5 days, into Te-125m; and (2) transition of Te-125m to stable Te-125, with a half-life of 58 days, either by internal conversion or by emission of gamma radiation.

The decay scheme is not simple. A total of 143 gammas is given off per one hundred decays of I-125. Eighty-five percent of all the gamma radiation emitted has a narrow energy spectrum, 27.5 - 31.7 keV. The remaining activity is divided between 3.7 keV (13.3%) and 35.4 keV (4.2%) photons.

The new low pH I-125 compounds should not be stored at freezing temperatures. It appears that with the low pH, the iodine volatility increases with freezing.

I-125 Radiation Protection Data

Radiations: Gamma 34.4 keV (7%)
X-Rays 27 - 32 keV (140%)

Dose rate at 1 cm from a 1 millicurie bare droplet of I-125 solution: approximately 600 mrem/hr.

Dose rate from a 0.1 ml I-125 solution in a typical glass vial: 400 mrem/hr per millicurie at contact, and 150 mrem/hr per millicurie at 1 cm.

For iodine concentrating in the thyroid gland, the maximum permissible thyroid burden is 1150 nanocuries, corresponding to a thyroid dose of 4 rem/year.

Always shield millicurie quantities of iodine with at least 1 mm of lead.

Appendix 2 (cont.)

B. ORDER AND RECEIPT OF RADIOACTIVE IODINE

As with all radioactive material, I-125 may be ordered following RSO approval. The radioactive material should be ordered in combi-vials or combi-v-vials, sealed with a rubber septum.

Upon receipt of a package, prior to opening, check it for dose rates and surface contamination, prior to opening. The package should be opened with gloved hands. As with other radioactive materials packages, the contents should be considered contaminated until smears of the vial show otherwise. If the package appears damaged or leaking, call the Radiation Safety Officer.

Some investigators have received shipments of I-125 in small volumes in which it appeared as if liquid was not present. Cool the shipping vial in a refrigerator prior to attempting to remove the activity. If the vapor does not condense, then add an additional volume of carrier solution. If the activity has been lost, notify the Radiation Safety Officer.

C. RADIOACTIVE IODINE CONTROL

Iodine 125 and 131 MUST be handled in fume hoods with air flows exceeding 100 linear feet per minute.

D. THYROID MONITORING

The greatest hazards from I-125 are due to ingestion, absorption through the skin, or inhalation rather than from external exposure to the relatively weak radiation. Persons who work with any of the radionuclides of iodine are required to have routine thyroid uptake measurements at quarterly intervals. The thyroid uptake is a simple, non-invasive procedure, and requires only a few minutes to complete. The Radiation Safety Officer notifies in writing all licensed users who have received quantities of radioiodine during the preceding quarter that uptakes are upcoming. Upon receipt of this notice, schedule thyroid uptakes for your laboratory personnel. Exempted are persons using less than 10mCi of I-125 and I-131 over a three month period, if the iodine is bound to nonvolatile agents.

The volatile iodine species which is responsible for contamination and ingestion via airborne routes in the laboratory is the elemental diatomic form I_2. In most cases, the stock solution is under iodine pressure as long as the container remains capped.

Appendix 2 (cont.)

When uncapped, the gaseous contents escape, and the iodine solution begins to volatize rapidly, causing contamination of the surrounding air. Agitation of the container or heating the solution will augment the process.

The special hazard connected with several of the commonly used chemical forms of radioiodine is the ease with which the bound iodine can be oxidized to elemental iodine. Most solutions consist of sodium iodide, NaI. The iodide ion is the anion of a strong acid and is fully ionized in water. It is also oxidized to iodine by atmospheric oxygen. In ordinary usage, the ease with which radioiodine can be ingested cannot be overemphasized.

It should be noted that, although all chemical forms are not localized in the thyroid, many forms may contain substantial fractions of uncombined iodine. It is, therefore, recommended that a baseline thyroid survey be arranged prior to the first use of any radioiodine labeled material and again within 24 hours after the first use of iodine compounds; subsequently, during continued use, thyroid uptakes are required at scheduled quarterly intervals. In addition, individuals are requested to call the Radiation Safety Officer if they suspect that they may have been exposed to airborne radioiodine or if they believe that they might have ingested or otherwise have allowed radioiodine to enter their bodies.

E. HANDLING RADIOACTIVE IODINE

The following safety recommendations are made in order to reduce possible internal and external contamination and to aid you with your experimental process. These suggestions are made for both the researcher performing iodinations and those using small quantities of labeled iodine.

1. Ways to reduce iodine absorption through the skin

a. Always wear a lab coat, preferably buttoned at the neck.
b. Rubberized oversleeves should be worn to prevent volatile I-125 from going up the lab coat sleeve.
c. Wear two pairs of gloves as radioactive iodine will be absorbed through one pair. Polyethylene gloves are best.

Appendix 2 (cont.)

2. Equipment to be used

a. Film badge
b. Lead shielding (1-2 mm of lead for I-125)
c. Radiation detector. A G-M detector is good only to indicate gross contamination. A thin wafer scintillation detector which can be left on during work is desirable.
d. Air monitoring equipment where available.

3. Working Procedures

a. Always handle millicurie quantities of I-125 in a fume hood that has a flow of at lease 100 linear feet per minute.
b. Prepare the hood or work bench area with absorbent paper.
c. Turn on any available air sampling apparatus; iodine isotopes may be discharged into the atmosphere as molecular iodine or as inorganic or

organic iodides, depending on their origin. Any releases must be in compliance with Nuclear Regulatory Commission regulations.

d. Always wear two pairs of gloves when handling iodine.
e. When possible, use forceps when handling I-125 vials.
f. Never remove the rubber vial septum. In addition to the radiation hazard of inhaled I-125, repeated opening and closing of an isotope vial without the rubber septum will result in an appreciable loss of water by evaporation, which changes the concentration of extraneous salts and leads to unpredictable pH fluctuations in the final reaction mixture. REMOVE ALL NEEDED ALIQUOTS WITH SPECIAL SYRINGE NEEDLES.
g. If possible, have a radiation detector on during the iodination.
h. All glassware and equipment should be marked as radioactive.

Appendix 2 (cont.)

i. When withdrawing from the hood or work area remove the outer pair of gloves. Liquid waste should be made alkaline while still in the hood. Liquid waste containers used for storage of iodine waste should be stored tightly capped in a hood.
j. Dispose of or clean contaminated apparatus and glassware as quickly as possible to minimize release of volatile iodine into the hood or room air. Contaminated items, such as vials, syringes, pipette tips, etc., should be wrapped in a double polyethylene bag, taped securely and placed immediately in containers designated “radioactive waste.”
k. If a spill has occurred or equipment must be decontaminated, immediately wipe the surfaces with a solution consisting of 0.1 M NaI, 0.1 M NaOH, and 0.1 M $Na_2S_2O_3$. This helps to stabilize the material and minimize evolution of volatile species. Proceed then with a detergent or decontaminant to complete the clean-up.
l. Use the above described solution in liquid waste containers to stabilize any iodine waste.
m. Upon re-entry into the hood area, put on another pair of gloves.
n. Before leaving the lab or work area, monitor your person and materials for contamination and wash your hands thoroughly.

4. Use of Vacuum Pumps with Radioactive Iodine

After iodinating, researchers often perform a separation procedure involving the vacuum withdrawal of a supernate into a flask. For this procedure, use a local vacuum pump in a hood appropriate for iodine work. Label all equipment with radioactive tape. The house vacuum line may <u>not</u> be used for this procedure. In order to reduce contamination, place an iodine trap between the flask used for collecting the supernate and the vacuum source. A suitable trap consists of a one liter, thick-walled, side-arm vacuum flask containing 600 - 700 ml. of 1M sodium metabisulfite solution. With the vacuum turned on slightly, the supernate can be slowly withdrawn. Simultaneously, the atmosphere of the flask containing the withdrawn supernate is sucked into the trap and passed down through a tube to the bottom of the flask. Here the gas slowly bubbles upward through the sodium meta-bisulfite solution which traps the elemental iodine. This is a colorimetric trap because the sodium metabisulfite, originally clear, turns gray when sufficient iodine has been trapped to warrant changing the solution. Lead foil can be wrapped around the trap to protect the trap from light and to protect personnel from radiation.

Appendix 3

PHOSPHORUS-32 CONTROLS

P-32 is now used widely in tracer experiments. This isotope emits an energetic 1.71 MeV beta particle and must be handled with care. P-32 radiation can be absorbed in three (3) ways: as a radiation source external to the body, in contact with the body, and inside the body.

The range in air of this beta particle is approximately twenty (20) feet. Local shielding is always recommended. When shielding for beta radiation, bremsstrahlung radiation must be taken into account. When a stream of beta particles strikes a target, electromagnetic radiation called bremsstrahlung is produced. The yield of this radiation is directly proportional to the energy of the charged particle (beta) and the atomic number of the target material. Therefore, the primary shielding for P-32 should be a low density material such as plastic to minimize the bremsstrahlung effect. The secondary shield should be of high density material to absorb the bremsstrahlung which may have been produced.

One of the greatest hazards associated with beta emitters of this energy level exists when handling uncovered samples. The dose rate at the surface of a one (1) ml solution containing one (1) millicurie of P-32 is approximately 13 rem/minute. This dose rate will of be appreciably reduced by attenuation in a few centimeters of air. A hand or face over such an open container may receive a considerable dose in a short period of time.

Most P-32 labeled chemicals do not present an inhalation problem. However, many that are commonly used are readily absorbed through the skin. Also, there is a possibility that transferrable contamination will be ingested or become airborne and possibly inhaled.

The maximum permissible body burden is thirty (30) microcuries. The maximum permissible burden for the bone is six (6) microcuries (the critical organ). Approximately 60% of ingested P-32 is excreted within the first 24 hours, and only about 1% per day is excreted after the second or third day following ingestion. When a bioassay program is necessary, urine samples should be submitted regularly for analysis. Dose evaluation requires knowledge of the approximate date and time of exposure.

RECOMMENDED SAFE PRACTICE INSTRUCTIONS

1. Use both low and high density shielding materials (low density nearest the source).
2. Use remote handling tools.
3. Protect eyes from chemical splash and unnecessary radiation. Personnel using quantities greater than 500 microcuries shall wear safety glasses.
4. Wear gloves—two pairs of gloves might be helpful. Remove gloves inside the hood and store properly.
5. If skin contamination is suspected, promptly wash with soft soap and plenty of water. If this is not successful, a suitable solvent may be used if caution is exercised not to injure the skin.
6. When bioassay is required, a urine sample should be submitted within twelve (12) hours after using P-32.
7. Film badges or thermo-luminescent dosimeters (TLD) should be used by ALL PERSONNEL working with P-32. If millicurie quantities are used, a dosimeter to measure doses to the extremities should also be used.
8. A GM survey instrument should be used to check the work area during and after the use of P-32.
9. Work under an approved fume hood to prevent inhalation.
10. Clean work area after each operation and store waste properly.
11. If a spill should occur, isolate the area and notify the Radiation Safety Officer.
12. Dispose of all radioactive waste according to regulations. P-32 may be stored with suitable shielding and allowed to decay. After 4 half-lives, less than 10% of the original activity remains; after 7 half-lives, less than 1%; after 10 half-lives, less than 0.1%.